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ENVIRONMENTAL QUALITY OF ROSE CREEK AS AFFECTED BY DISCHARGES FROM THE CYPRUS ANVIL MINE, YUKON TERRITORY (1983)

Regional Program Report No. 85-12

by

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ABSTRACT

An assessment of the water quality and biological conditions of Rose Creek, adjacent to Cyprus Anvil mine, was carried out during the summer of 1983. The water quality, sediment and bottom fauna characteristics were documented at 10 environmental quality monitoring stations. Water quality information from Cyprus Anvil Mining Corporation's 21 Surveillance Network Stations was evaluated.

Environmental quality monitoring program results have indicated an improvement in the water quality of Rose Creek since the CAMC's June 15, 1982 mine shutdown. Sediment analysis have revealed little change to previous studies. Benthic invertebrates have increased in abundance compared to previous studies and bioassays with Daphnia pulex showed no acute toxic effect from the tailings pond seepage. The surveillance network indicated incidents of non-compliance in 1982-83 with elevated levels of zinc at the tailings pond and in the winter months of 1983-84 at the north fork of Rose Creek.

RESUME

Une évaluation de la qualité et des conditions biologiques de l'eau de ruisseau Rose adjacent à la mine Cyprus Anvil, fut entrepris durant l'été 1983. La qualité de l'eau, les caractéristiques des sédiments et de la faune benthique ont été analysées at dix stations d'échantillonnage pour l'évaluation de la qualité environnementale. Vingt-une stations on été échantillonnés pour la qualité de l'eau du programme de surveillance a la Corporation Miniere Cyprus Anvil.

Les résultats ont indiques une amélioration de la qualité de l'eau de ruisseau Rose durant de la période inopérante de la mine. L'analyse des sediments montre un accroissement important du niveau de métaux lourds aux stations intermediaires du ruisseau, qui doivent être reliés au déversement des bassins de décantation en 1975. Les invertebres benthiques augmentent en abondance et les bio-essais avec Daphnia pulex ne montrent aucune toxicité aigu des infiltrations des bassins de décantation. Le programme de surveillance indique par contre des incidents non conforme au permit en 1982-83, indicant de hautes concentrations de zinc aux bassins de décantation et aux mois d'hiver 1983-84 dans la branche nord du ruisseau Rose.

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1 INTRODUCTION

The Environmental Protection Service (EPS) has monitored the biological communities, water quality and sediment characteristics of Rose and Anvil Creeks near the Cyprus Anvil mine since 1973 (Hoos 1973, Baker 1979, Weagle 1981). The purpose of these studies is to ensure that the receiving water quality downstream of the mine is not being seriously degraded. This 1983 study updates the environmental quality monitoring information and utilized the same station locations in most cases as previous surveys. These efforts compliment the biological monitoring program presently required as part of the water licence for the Cyprus Anvil Mine Corporation (CAMC).

Mining activity at the time of the survey consisted only of stripping overburden and waste rock covering the ore body to the east of the main pit. No processing of ore has occurred since June 1982 when the mill was shut down for an indefinite period.

The results of this survey are compared to results obtained in previous years to provide a relatively detailed picture of the environmental quality of Rose Creek and Anvil Creek.

Also included in the report is a section on water quality compliance based on the program as defined by the CAMC water licence.

2 STUDY AREA

The Cyprus Anvil Mine Corporation (CAMC) operates a lead-zinc -silver mine situated in the Anvil Range near Faro (62°20'N, 133°25'W) about 240 kilometres (150 miles) by air north of Whitehorse, Yukon (Figure 1). The mine area is drained by Rose Creek, Faro Creek and the north fork of Rose Creek (Figure 2). Rose Creek joins, 17km downstream of the mine, with Anvil Creek which in turn joins the Pelly River 64km from the mine. Figure 2 depicts and Table 1 describes sample stations for the environmental quality monitoring component of the study. Figure 3, an enlargement of the mine site area, shows station numbers and locations which are specified in the CAMC water licence for water quality compliance sampling. Table 2, describes the locations of the compliance monitoring network stations and details the activities regularly conducted by CAMC at each station.

There is some overlap of sampling stations between the environmental quality stations and the compliance monitoring network. These are identified in Figure 3 and described in Tables 1 and 2.

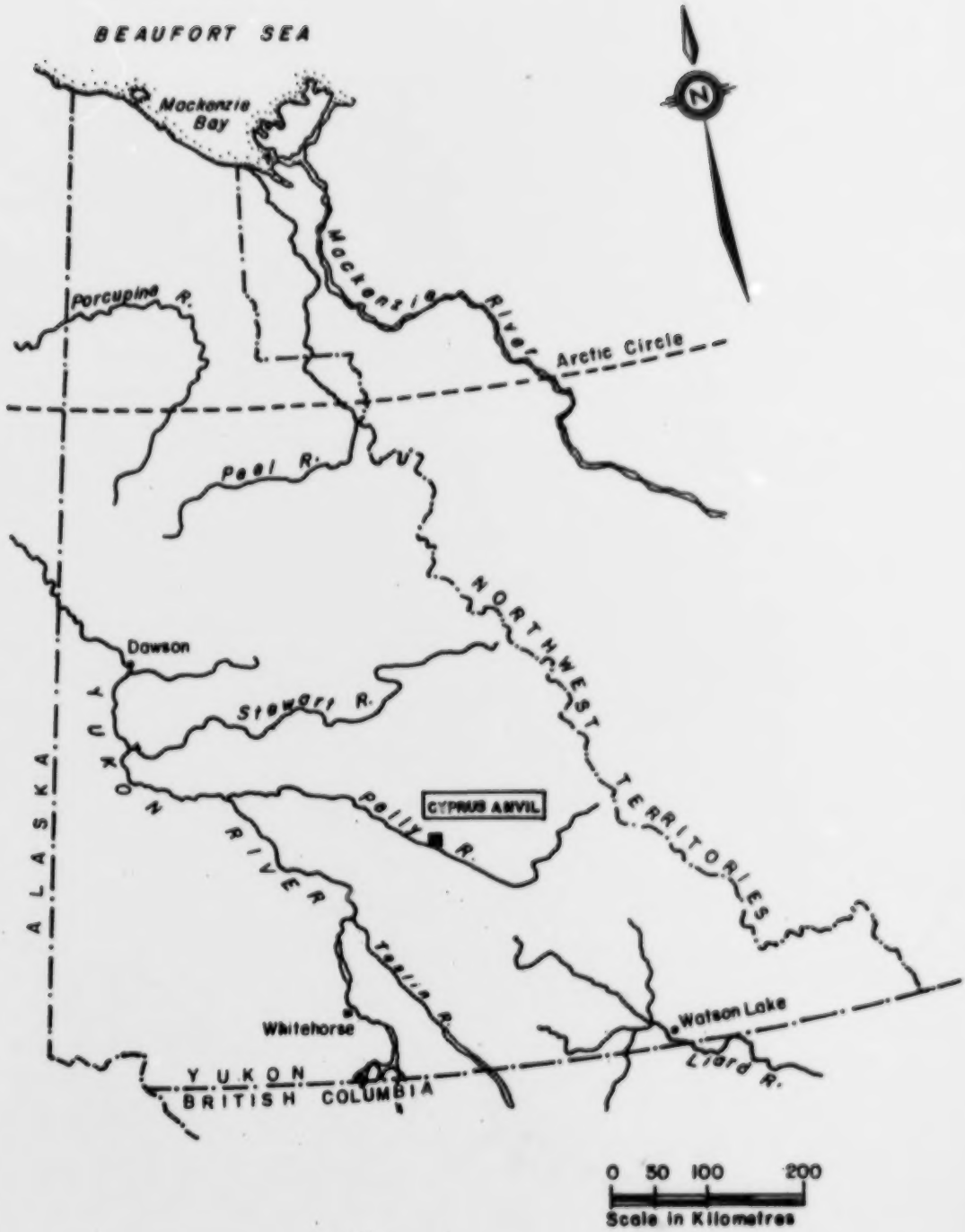


FIGURE I GEOGRAPHIC LOCATION OF CYPRUS ANVIL MINING CORPORATION LTD.

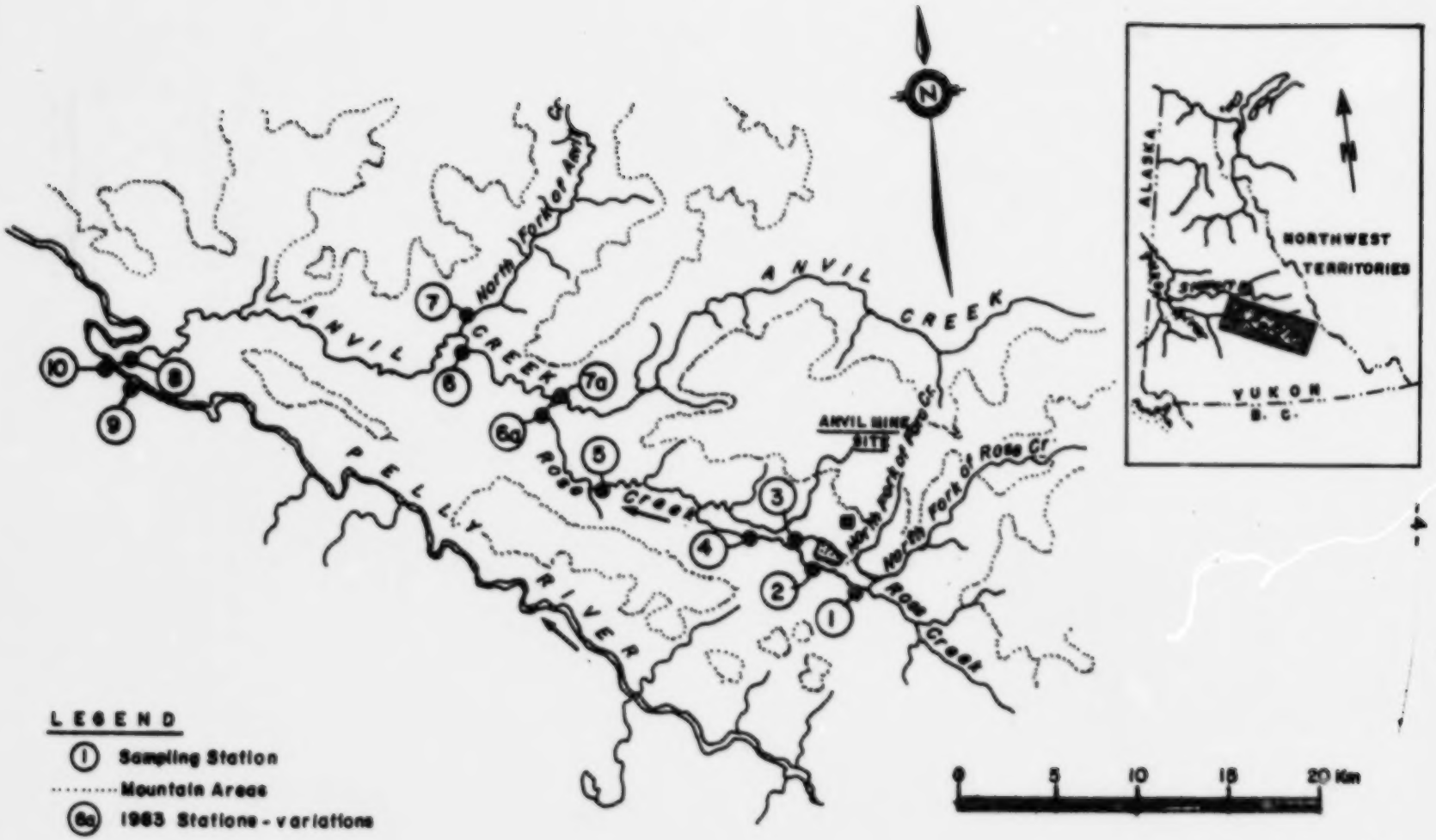


FIGURE 2 ENVIRONMENTAL QUALITY MONITORING SAMPLE STATION LOCATIONS

TABLE 1 STATION DESCRIPTIONS OF THE ENVIRONMENTAL QUALITY MONITORING LOCATIONS

EPS STATION	STATION LOCATION DESCRIPTION
1	On Rose Creek, above the influence of the mine and mill effluent, 250 meters upstream of the north fork of Rose Creek confluence and compliance monitoring network Station X-3. Stream bed consists of boulder, cobbles, coarse and fine gravel.
2	On the diversion canal, near the new tailings pond, 700 meters upstream of compliance monitoring network Station X-10. Canal bed consists of mainly big boulders, cobbles and minor fine sediments.
3	Combined seepage flows from X-11 and X-12 upstream of decant confluence. The same location as compliance monitoring network Station X-13. Stream bed consists of coarse and fine gravel.
4	On Rose Creek, 1 km downstream of the entry of decant stream. Streambed consists of cobbles and coarse gravel.
5	On Rose Creek, about 5km above the confluence with Anvil Creek. Streambed consists of cobbles, coarse and fine gravel.
6	On Anvil Creek, above confluence with the north fork of Anvil Creek.
6a	On Rose Creek, above the confluence with Anvil Creek. The same location as compliance monitoring network Station X-15. Stream bed consists of boulders, cobbles, and coarse gravel.
7	On north fork of Anvil Creek, upstream of the confluence with Anvil Creek.
7a	On Anvil Cr., upstream of the confluence with Rose Creek. Streambed consists of coarse and fine gravel and sand.
8	On Anvil Creek, upstream of the confluence with the Pelly River. Stream bed consists of coarse and fine gravel and sand.
9	On Pelly River, upstream of the confluence of Anvil Cr. Stream bed consists of cobbles, coarse and fine gravel.
10	On Pelly River, downstream of the confluence of Anvil Creek. Stream bed consists of cobbles, coarse and fine gravel.

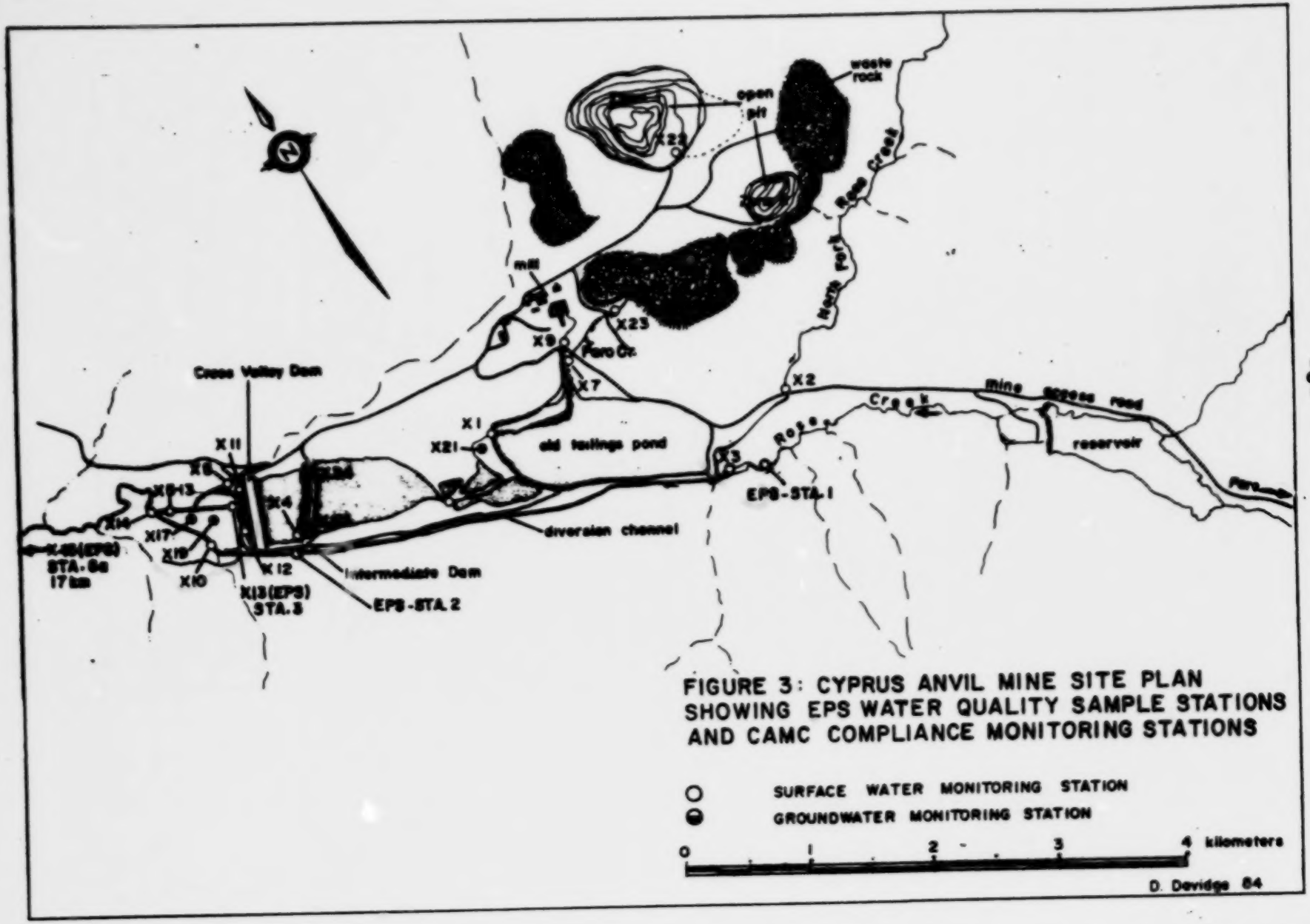


FIGURE 3: CYPRUS ANVIL MINE SITE PLAN SHOWING EPS WATER QUALITY SAMPLE STATIONS AND CAMC COMPLIANCE MONITORING STATIONS

TABLE 2 CYPRUS ANVIL MINING CORPORATION - SURVEILLANCE NETWORK PROGRAM

Parameters Monitored:	pH, Temperature, Suspended Solids, Flow, Ammonia (NH_3), Copper (Cu), Lead (Pb), Zinc (Zn), Cyanide (CN), Manganese (Mn) and Sodium (Na).
IDENTIFICATION NUMBER	**DESCRIPTION OF SAME STATION AND PARAMETERS**
X-2	North Fork Rose Creek, upstream of mine road bridge; sampled monthly for all parameters.
X-3	Rose Creek freshwater at pumphouse; sampled monthly for all parameters.
X-4	Intermediate Dam decant; sampled weekly for all parameters.
X-5	Cross Valley Dam decant; sampled weekly for all parameters.
X-7	Mine water at road crossing; sampled monthly for all parameters except Na.
X-10	Rose Creek Diversion Canal below wiers; sampled monthly for all parameters.
X-11	Seepage from north toe of the Cross Valley Dam; sampled weekly for all parameters.
X-12	Seepage from south toe of the Cross Valley Dam; sampled weekly for all parameters.
X-13	Combined seepage flows from X-11 and X-12 upstream of decant confluence; sampled weekly for all parameters.
X-14	Rose Creek downstream of diversion canal, seepage channel and decant channel confluences; Sampled monthly for all parameters.
X-15	Rose Creek at mouth. Sample site is the same as EPS Station 6(a).
X-16, X-17, X-18 X-19, X-20, X-21	Groundwater monitor wells K-1 to K-6 sampled every two months for all parameters except flow and CN.

TABLE 2 CYPRUS ANVIL MINING CORPORATION - SURVEILLANCE NETWORK PROGRAM (Continued)

Parameters Monitored:	pH, Temperature, Suspended Solids, Flow, Ammonia (NH_3), Copper (Cu), Lead (Pb), Zinc (Zn), Cyanide (CN), Manganese (Mn) and Sodium (Na).

IDENTIFICATION NUMBER	DESCRIPTION OF SAME STATION AND PARAMETERS
X-22	Discharge from Faro #1 Pit pumps; sampled weekly for pH, suspended solids, NH_3, Cu, Pb, Zn and Mn.
X-23	Pit drainage at toe of waste rock pile upstream of X-7; sampled weekly for pH, suspended solids, NH_3, Cu, Pb, Zn and Mn.
X-24, X-25	Groundwater station monitor wells I.D.2 and I.D.6; sample every two months for all parameters except flow and CN.

3 METHODS

Environmental quality monitoring of the 10 different stations at CAMC was done on July 26 and September 15, 1983. All sample stations are in similar locations to past studies by Environmental Protection Service except stations 6 and 7. The 1983 sampling program altered Station 6 to be on Rose Creek upstream of its confluence with Anvil Creek instead of on Anvil Creek (Figure 2) and Station 7 to be on Anvil Creek upstream of the Rose Creek confluence instead of the north fork of Anvil Creek. Access to station 1 - 3 was by road and to stations 4 - 10 was by helicopter. The historic EPS monitoring stations will be referred to by number whereas the 1983 stations 6 and 7 are accompanied by a letter [6 (a) and 7 (a)]. Information was collected on water quality and quantity, sediment characteristics and benthic invertebrates at each station. In addition, bioassay testing and attached algal tissue analysis were performed on samples from specific stations.

3.1 Water Quality and Quantity

Water samples were collected in triplicate on July 26 and in duplicate on September 15, 1983. Sample collection, preservation, and analysis methods are described in Appendix 1, Table 1. Flow measurements were taken on July 26, 1983 using a Price type AA electronic current meter, except for Stations 9 and 10 on the Pelly River. The Pelly River was too large to sample with the equipment available. When taking flow measurements, an area with a uniform cross section was chosen for the metering. Ten readings were taken across the profile of the stream at each station whenever possible. Total discharge was calculated as the summation of these fractional discharges. Water quality field measurements included temperature, conductivity, pH and dissolved oxygen. Replicate values were not collected for these parameters. Most of the analyses were conducted at EPS Laboratory Services, 4195 Marine Drive, West Vancouver, B.C. These included pH, conductivity, color, turbidity, non-filterable residue,

total alkalinity, total hardness, total phosphates, nitrites, nitrates, ammonia, sulfate, chloride and the following extractable metals:

Aluminum (Al)	Cobalt (Co)	Selenium (Se)
Antimony (Sb)	Copper (Cu)	Silicon (Si)
Arsenic (As)	Iron (Fe)	Silver (Ag)
Boron (B)	Lead (Pb)	Sodium (Na)
Barium (Ba)	Magnesium (Mg)	Strontium (Sr)
Beryllium (Be)	Manganese (Mn)	Tin (Sn)
Cadmium (Cd)	Molybdenum (Mo)	Titanium (Ti)
Calcium (Ca)	Nickel (Ni)	Vanadium (V)
Chromium (Cr)	Potassium (K)	Zinc (Zn)

The percent dissolved oxygen saturation (% DO) was calculated by first determining the dissolved oxygen saturation concentration (S') from the formula:

$$S' = S \frac{P}{760} \text{ (APHA et al 1975)}$$

where S' = dissolved oxygen (DO) saturation concentration at the in situ temperature and atmospheric pressure

S = dissolved oxygen (DO) saturation concentration at sea level for in situ temperatur

P = atmospheric pressure in millimeter of mercury (mm Hg) at site elevation

The percent dissolved oxygen saturation was obtained by using the ratio of field dissolved oxygen and S' in the following formula:

$$\frac{\text{Field DO}}{S'} \times 100 = \% \text{ DO Saturation}$$

where Field DO = Dissolved Oxygen concentration measured in the field

3.2 Sediment

Sediment samples were collected at the same time as water samples. Sediments were collected near the bank below the water level, and selected for their representativeness of the streambed as much as

possible. Three sediment samples were collected at each site using an aluminum shovel to scoop the samples into pre-labelled geochemical sampling bags within Whirl-Pak™ bags. A description of sediment collection, preparation and analysis methods is given in Appendix I, Table 2. All sediment samples were air shipped to Vancouver for analysis at Laboratory Services, Environmental Protection Service, 4195 Marine Drive, West Vancouver, B.C. The replicate sediment samples were each analysed for particle size and the following leachable metals.

Aluminum (Al)	Iron (Fe)	Silicon (Si)
Arsenic (As)	Lead (Pb)	Silver (Ag)
Barium (Ba)	Magnesium (Mg)	Sodium (Na)
Beryllium (Be)	Manganese (Mn)	Strontium (Sr)
Cadmium (Cd)	Mercury (Hg)	Tin (Sn)
Calcium (Ca)	Molybdenum (Mo)	Titanium (Ti)
Chromium (Cr)	Nickel (Ni)	Vanadium (V)
Cobalt (Co)	Phosphorus (P)	Zinc (Zn)
Copper (Cu)	Potassium (K)	

3.3 Bottom Fauna

Bottom fauna collection, preservation and identification methods are summarized in Appendix I, Table 3. The benthic invertebrates were sampled at each of 10 stations using an artificial substrate sampler. The samplers were placed in the stream on July 26, 1983 and left to colonize for 50 days before retrieving on September 15, 1983. Three replicate samples were collected at each station. The substrate used in the artificial substrate samplers was taken directly from the streambed at each stations and consisted of rock sizes ranging from 1cm to 8cm in size. The rocks were not washed or brushed in order to loosen debris, sediment and benthic invertebrates. The maximum volume of the artificial substrate sampler is 0.0057 m^3.

The samplers were located in the creeks at various depths (30-60 cm) along a cross-section of the stream, deep pools and fast currents were avoided. A plankton net (mesh opening 0.76 mm) was used to capture any organisms lost from the sampler during retrieval.

3.3.1 Diversity/Evenness Indices. Diversity/evenness indices were calculated from the bottom fauna data using the Shannon-Weiner diversity index described by Pielou (1975) and modified as follows:

$$\text{Species Diversity } (H') = -\sum_{i=1}^{g} (P_i \log_{10} P_i)$$

where $P_i = n_i/N$

n_i = total number of individuals in the i^{th} genus

N = total number of individuals identified to genus level and/or species taxonomic level in one sample

g = total number of genera in one sample

The use of individuals identified to genus level instead of to species level results in slightly lower and conservative diversity index (H') values (Hughes, 1978). Individuals that were not identified to genus or species level, were not included in the the Species Diversity calculation but are listed collectively with all individuals that were (Appendix IV, Tables 1 and 2).

The diversity of the benthic invertebrate community depends on the number of species and the evenness with which the individuals are apportioned among them. The method of measuring evenness used in this report is described by Pielou (1975) and is given by the formula:

$$\text{Evenness } J' = \frac{H'}{\log g}$$

where H' = the species diversity

g = the number of species

3.2.2 Community Index. The benthic communities were also analysed using the Percent similarity index (Psc) as the community index, comparing each station to other stations using the formula as described by Brock (1977).

$$Psc = 100 - 0.5 \sum_{k} |a-b|$$

where a and b are, for a given genus, percentages of the total samples A and B which that genus represents. The absolute value of their difference is summed over all genera, k.

3.4 Attached Algae. Tissues of a filamentous algae (Class Bacillariophyceae) from Station 3 (seepage) were analysed for extractable metals. The analysis involved one sample on July 26 and three on September 15, 1983.

3.5 Bioassay. Duplicate bioassay samples were collected at Station 1 (Rose Creek) and a single sample at Station 3 (seepage) on July 25, 1983. The bioassays were performed at the Whitehorse EPS laboratory using Daphnia pulex. The results involved an acute toxicity test for 48 hours (48h-LC_{50}) and 96 hours (96h-LC_{50}).

3.5.1 Control Water Details. The tap water used for dilutions of bioassays and experimental controls originated from the City of Whitehorse water supply. The water was filtered through a carbon filter and aged to ensure dechlorination. The water was aerated to saturation with oxygen and adjusted to 20°C prior to use.

3.5.2 Test Organism Culture. The Daphnia pulex culture originated from EPS Atlantic Region. The Daphnia pulex population was adapted to a light cycle of 16 hours of day and 8 hours of night. Culture temperatures were kept between 20-23°C, pH 7.5-8.2 and dissolved oxygen (DO) 5.0-8.0 ppm. Feeding occurred three times a week and included a composition of trout chow, yeast and cerophyll®. The test organisms used, were less than 48 hours old. The criteria for the acute toxicity test was the mortality of the organisms as defined by the lack of antenna, phyllopodes or abdominal movements. Two different exposures were performed, a 48 hour test for Station 1 (Rose Creek) and a 96 hour

test for Station 3 (seepage). The tests were conducted at 20°C with no aeration in the 200 ml test vessels. The loading density was one Daphnia pulex per 20 ml.

3.5.3 Statistics. Statistical treatment of the replicate data involved calculating the arithmetic mean ($\bar{x}$) and standard deviation (S.D.). Certain comparisons involved the use of confidence limits using the Student's t-distribution for small samples and correlations (r). The formula used for these calculations are according to Sokal and Rohlf (1981).

4 RESULTS AND DISCUSSION

4.1 Water Quality Physical and Chemical Parameters

Data of the replicate water chemistry collected is presented as an arithmetic mean ($\bar{x}$) and standard deviation (S.D.) for each station in Tables 1 and 2 of Appendix II. Figures 4 to 9 provide graphic representation of the trends of selected parameters, their distribution and mixing in the stream.

4.1.1 Flow. Flow measurements were taken only on July 26, 1983 and variations in the flow regime between the two sampling periods can be assessed only by water level observations on the river bank. September 15, 1983 water levels were equal to or higher than July 26, 1983 at all stations. The increase in flow between Stations 1 and 2 on July 26 is a result of increases from the north fork of Rose Creek and Faro Creek. The cross valley pond seepage, measured at Station 3 (compliance monitoring sampling Station X-13) remained unchanged during the sampling periods, with mixing proportions with Rose Creek being approximately 1:20 during July. The flow measured at Station 6(a) (Rose Creek) and Station 7(a) (Anvil Creek) were comparable, 4.50 and 4.32 m^3/sec respectively.

The Water Survey of Canada data collected for Rose Creek below Faro Creek (upstream of Station 2 on Rose Creek) is available for 1968 and 1969. The monthly means indicate the peak flow for the year is expected to occur during spring breakup (April-June) with a secondary smaller peak occurring before freeze up (Sept.-Oct.)(Hoos, 1973).

4.1.2 Dissolved Oxygen. Percentage dissolved oxygen (% DO) levels recorded at Stations 1-10 are illustrated in Figure 4 and listed in Appendix II Table 1. Rose Creek, Anvil Creek and north fork of Anvil Creek had stable percent dissolved oxygen (% DO) levels ranging between 85 and 98% saturation. Percent dissolved oxygen (%DO) at Station 3 (seepage from the toe of the Cross Valley dam) was 38% during both sampling periods. Station 9 (Pelly River) had a mean for both sampling

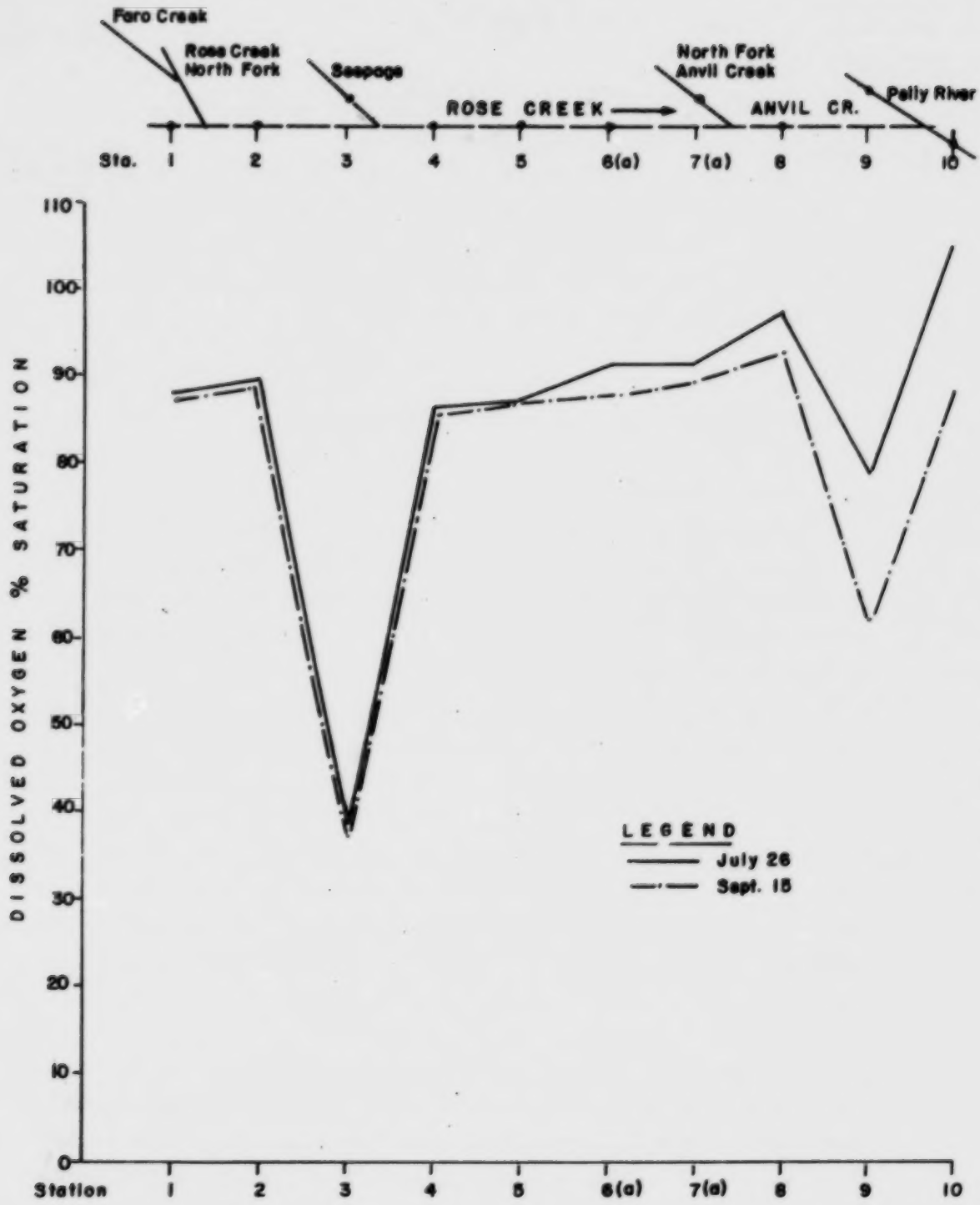


FIGURE 4 DISSOLVED OXYGEN-PERCENTAGE OF SATURATION-IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

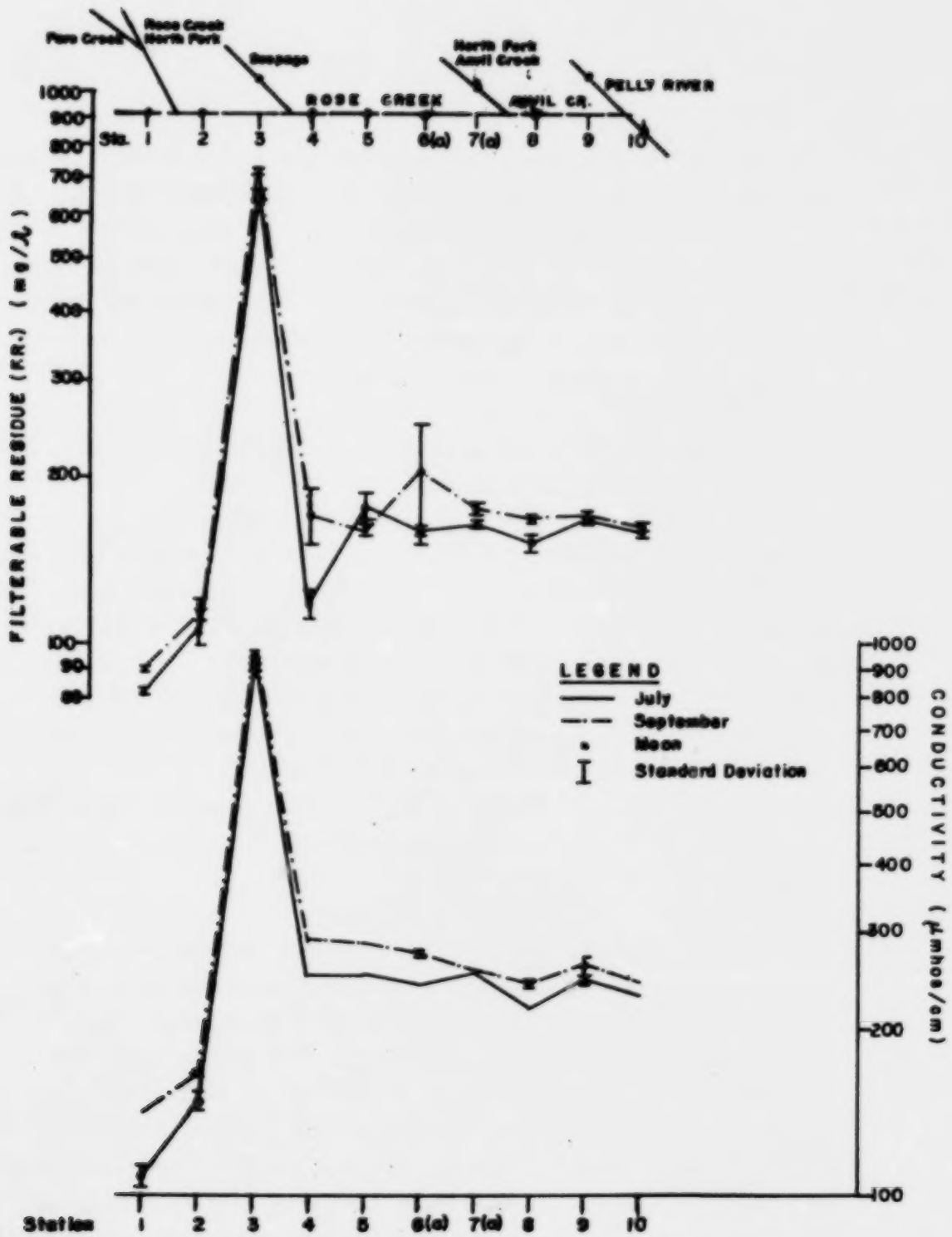
dates of 71% DO. The low % DO levels at Station 3 (seepage) indicate the source of flow may be partially from groundwater origin. The origin of the seepage (Station 3) is discussed to a greater extent later in the text. The results at Station 10 (Pelly River downstream of Anvil Creek confluence) suggest that Anvil Creek enhances the dissolved oxygen content in the river, at least along the north bank where the plume from Anvil Creek is located.

4.1.3 pH. The pH of the water in the study area tends to increase uniformly progressing downstream from Rose Creek Station 1 (pH 7.3) to Anvil Creek Station 8 of (pH 8.1). Laboratory pH varies less than 0.3 pH units between samplings on July 26, 1983 and September 15, 1983. Station 3 (seepage) averaged a pH of 7.6 whereas Station 2 (Rose Creek) averaged 7.8. McNeely (1979) indicates surface water generally tends to be alkaline, whereas ground waters are more acidic.

The data presented by Hoos (1973) and Baker (1979) present a similarity in the range and the spatial variation of pH as found in this study. Weagle (1981) found higher pH values ranging between pH 8 and pH 10 as far as Stations 4 and 5. The cause for these higher values was not discovered but suspected to be the reagent additives (lime) in the mill effluent.

4.1.4 Conductivity and Filterable Residue. Conductivity gives a measure of the ions in the water while filterable residue is a measure of the exact content of dissolved solids. As shown in Figure 5 for both parameters, Station 3 (seepage) adds a high input of mineral to the water. This impacts on the stream by increasing the level of minerals downstream relative to the upstream stations (Stations 1 and 2, Rose Creek). Once the seepage and Rose Creek are uniformly mixed, the level of mineral at downstream Station 5 (252-289 umhos/cm), is twice that of Rose Creek upstream of any mine influence (108-141 umhos/cm).

The conductivity values have varied temporally over the years Hoos (1973) reported spatial similarities in conductivity at most



NOTE: The Value for Conductivity in July for Station 4 to 10 represents One Sample

FIGURE 5 MEAN VALUES OF FILTERABLE RESIDUE (F.R.) AND CONDUCTIVITY IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

stations. In 1974 and 1976 all EPS laboratory conductivity values of downstream stations (4-10) ranged between 150-200 umhos/cm and tended to be lower than results of this study (228-289 umhos/cm). In 1975, the readings were in the same range as this study except for Station 2 (Rose Creek) which was lower (Baker, 1979). Baker (1979) has indicated that for the years that seepage from the tailings pond (EPS Station 3, X-13) has been measured, the conductivity has fluctuated greatly, from 136 umhos/cm to 94010 umhos/cm. Conductivity of the seepage at Station 3 (X-13) during this study had lab conductivity of 929-955 umhos/cm.

4.1.5 Color. Color of the water is a result of metallic ions and soluble coloured organic compounds remaining after the turbidity is removed. In July, color was equal to or higher than the September samples at upstream Stations 1-4. Downstream stations (Stations 5-10) in July had values less than or equal to the September samples. This may reflect heavy rains a few days prior to sampling and the increase of organics leached from the land which contain various humic acids that contribute to color.

4.1.6 Turbidity. Turbidity is an expression of the optical property in water that causes light to be scattered and absorbed rather than be transmitted in straight lines through a sample. The turbidity measured during this study is generally low, in the range of 0.10-0.20 FTU, but did show an increase at Pelly River Stations 9 and 10 with values up to 4.4 FTU (Figure 6). Turbidity at Pelly River Station 10 was slightly lower than Station 9 Pelly River as a result of the influence of Anvil Creek outflow. The higher level of turbidity in the Pelly River on the July sample date may be attributed to an increased level of rain induced colloidals and organic acids.

Comparison of our results with the previous studies (Hoos 1973, Baker 1979, Weagle 1981) clearly shows that low turbidity levels at sampling stations existed in 1983. Turbidity level comparisons of 1973 to 1978 are generally 10 to 20 times greater and 30 times greater in 1974, than our results. For those years, the turbidity levels at Rose Creek control station (Station 1) varied between 0.55 and 2.50 FTU higher than observed in 1983.

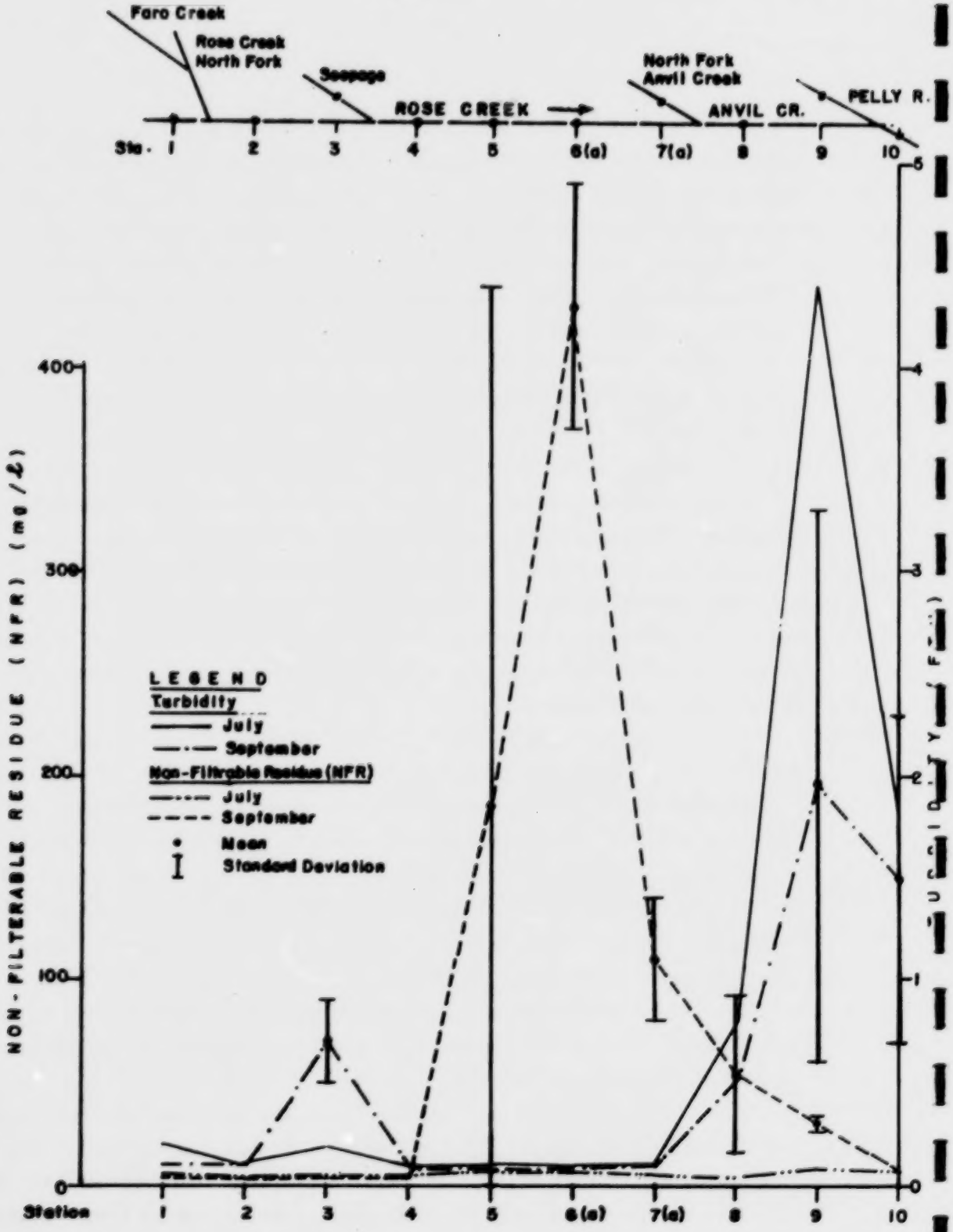


FIGURE 6 MEAN VALUES OF TURBIDITY AND NON-FILTERABLE RESIDUE (NFR) IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

4.1.7 Non-filterable Residue (NFR). The NFR or suspended solids is that portion of a sample remaining on a filter after filtration. NFR values (Figure 6) for all stations in July and September were at the detection limit (5.0 mg/l) except Station 5-10 in September where an incident caused by increased precipitation and resulting erosion was recorded. Figure 6 indicates a lack of correlation between NFR and turbidity values, particularly at Stations 5 to 7 in September when increased NFR values were not accompanied by an expected increase in turbidity. Station 5 (Rose Creek) in September, shows very high NFR variability as reflected by the standard deviation, indicating this Station to be a mixing zone.

4.1.8 Alkalinity and Hardness. Alkalinity is a measurement of the power of a solution to neutralize hydrogen ions (EPS, 1976). Hardness is principally determined by the sum of calcium (Ca) and magnesium (Mg). Alkalinity and hardness values follow similar patterns (Figure 7) temporally and spatial. Hardness and alkalinity were elevated in the tailings seepage (Station 3) relative to creek and river stations.

Station 7(a) (Anvil Creek) shows slightly higher alkalinity values than do stations on Rose Creek or further downstream. The difference in alkalinity between Rose and Anvil Creeks may be due to the neutralization of acidity generated from the tailings ponds at the Cyprus Anvil mine site. Previous studies (Hoos, 1973, Baker 1979, Weagle 1981) have shown similar patterns of alkalinity and hardness.

4.1.9 Total Phosphate. Phosphate levels are low for both Rose and Anvil Creeks. They vary from below detection limit (0.0050 mg/l) to 0.0080 mg/l $\pm$ .002. Station 9 (Pelly River) had a phosphate level on July 25 of 0.016 mg/l $\pm$ 0.002. These are lowered at Station 10 (Pelly River) as a result of Anvil Creek input to 0.010 mg/l $\pm$ 0.001. Phosphates are eliminated and recycled fairly quickly in streams and small quantities may actually occur in solution in the water (Hynes 1972).

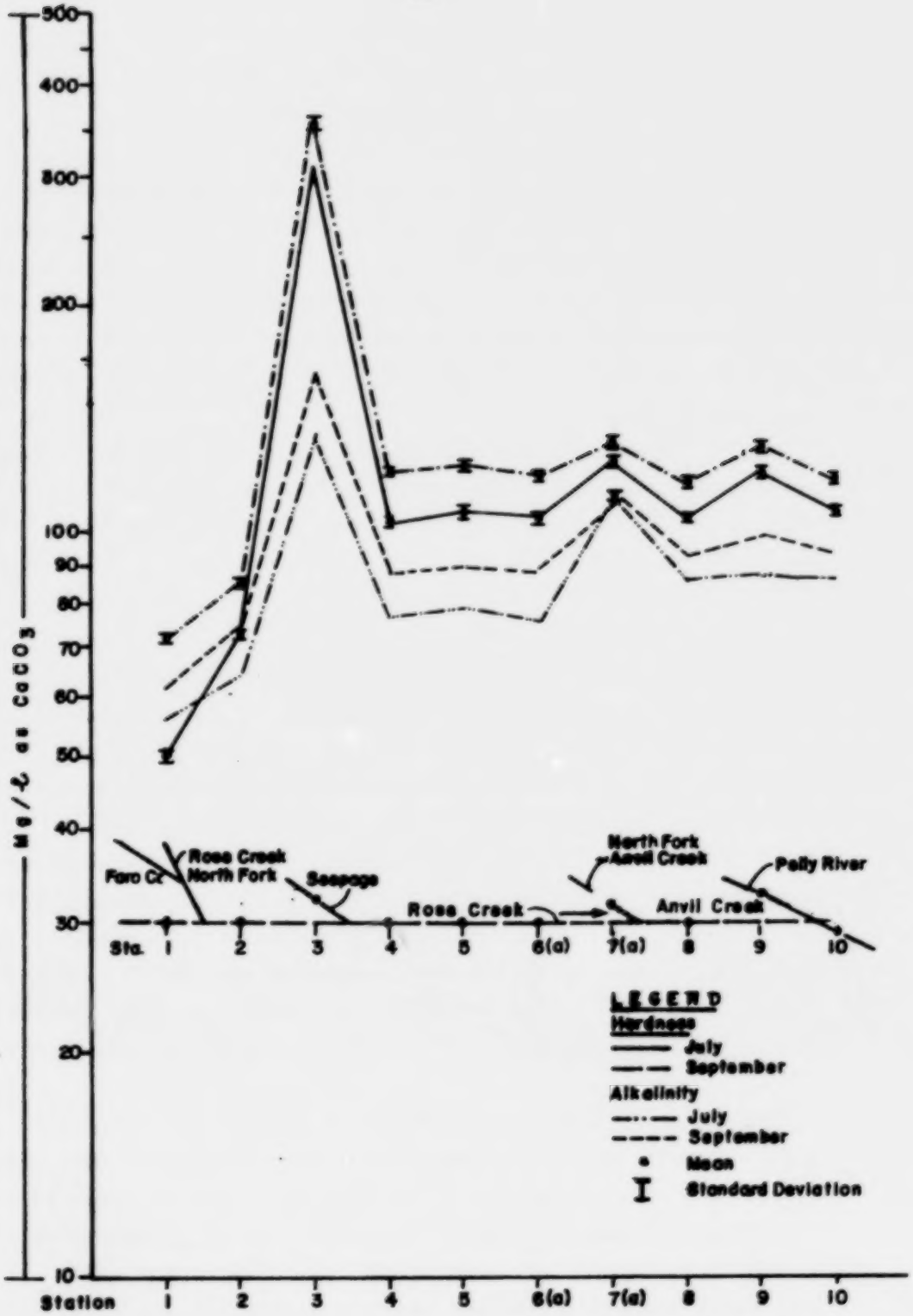


FIGURE 7 MEAN VALUES OF ALKALINITY AND HARDNESS IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

4.1.10 Ammonia. The levels of ammonia (NH_3) in the seepage water (Station 3) of 0.5 to 0.7 mg/l, are 2 orders of magnitude higher than in Rose Creek (Station 1)(Appendix II, Table 1). Ammonia (NH_3) is present in groundwater, particularly at colder temperatures(EPS, 1972). The toxicity of ammonia decreases with temperature, attributable to a decrease in the concentration of the un-ionized ammonia fraction, but increases at low oxygen concentrations. Yake and James (1983) report that at a pH of 7.5 to 8.0 and a temperature of 5°C, the percentage of un-ionized ammonia in an ammonia water solution is 0.4 to 1.0. Ammonia (NH_3) toxicity at Station 3 (seepage) increased at low oxygen levels to a concentration of 0.0106 mg NH_3/l. Recommended toxicity of ammonia is not to exceed 0.020 mg NH_3/l (Thurston et al, 1979). Some synergism occurs with cyanide, and ammonia toxicity is additive to the toxicity of zinc and copper (Thurston et al, 1979).

4.1.11 Nitrite and Nitrate. On July 25, 1983 nitrite levels at all stations were below the detection limit (<0.0050 mg/l) while in September the means of each station ranged from 0.0090 $\pm$ 0.0000 mg/l to 0.013 $\pm$ 0.0007 mg/l (Appendix II, Table 1).

The mean nitrate values ranged from less than the detection limit of 0.010 mg/l to 0.065 $\pm$ 0.004 mg/l. The amount of nitrate was higher in September than in July. The levels of those two nitrogen compounds were very low at the upstream Rose Creek stations (Stations 1 and 2) but increased significantly in September at the seepage location (Station 3). Knowing that the ammonia level is higher in the seepage at Station 3 (Appendix II, Table 1) indicates the process of transformation to a more oxidized form may occur. This transformation may also contribute to a certain extent to deplete the percent dissolved oxygen (% DO). Another cause of the difference between the two sample periods may be attributable to the rainfall and surface runoff experienced, which may contribute to increases in the level of nitrate in the stream (Hynes 1979).

4.1.12 Sulphates. The level of sulphates (Figure 8) at Station 3 (seepage) was 30-40 times greater than upstream Rose Creek Stations 1 and 2 (Appendix II, Table 1) on both sample dates. The mean amount varies in September from 468 ± 10.6 mg/l (Station 3 seepage) to 10.4 ± 0.07 mg/l (Rose Creek Station 1). This chemical is one of the major compounds responsible for the increase of conductivity, hardness, alkalinity and filterable residue at Station 3 (seepage). The potential hazard associated with a high concentration of sulphates, is that in acidic deoxygenated water, the sulfates could be reduced to the form of H_2S which is toxic to fish in its undissociated form to a level of 2 ug/l (Thurston et al 1979). In neutral and alkaline deoxygenated water, the sulfate will be reduced to the form of FeS which precipitates but when the iron is all utilized, the reduction will be to the form of H_2S. At Station 3 (seepage), ionized iron is still available and the alkalinity pH indicates further buffering available therefore there is little concern for the transformation of sulphate to sulphite.

The effect of sulphur from CAMC is highlighted when comparing levels at Station 7(a) (Anvil Creek) and Station 6(a) (Rose Creek) with mean values of 19 mg/l and 46 mg/l respectively. Cyprus Anvil's ores are massive sulfides consisting primarily of pyrite, pyrrhotite, galena and sphalerite. The tailings from this ore body are high in sulfide minerals and have been studied by others (Davidge, 1984).

4.2 Water Quality - Metals

4.2.1 Extractable Metal Analysis. The extractable metals in the waters of Rose and Anvil Creeks, the settling pond seepage and the Pelly River are given in Appendix II, Table 2. The mean ($\bar{x}$) values of the data from the July 26 survey is calculated from three grab samples while the September 15 survey is calculated on two grab samples.

For all the stations and on both sampling dates, silver (Ag), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr),

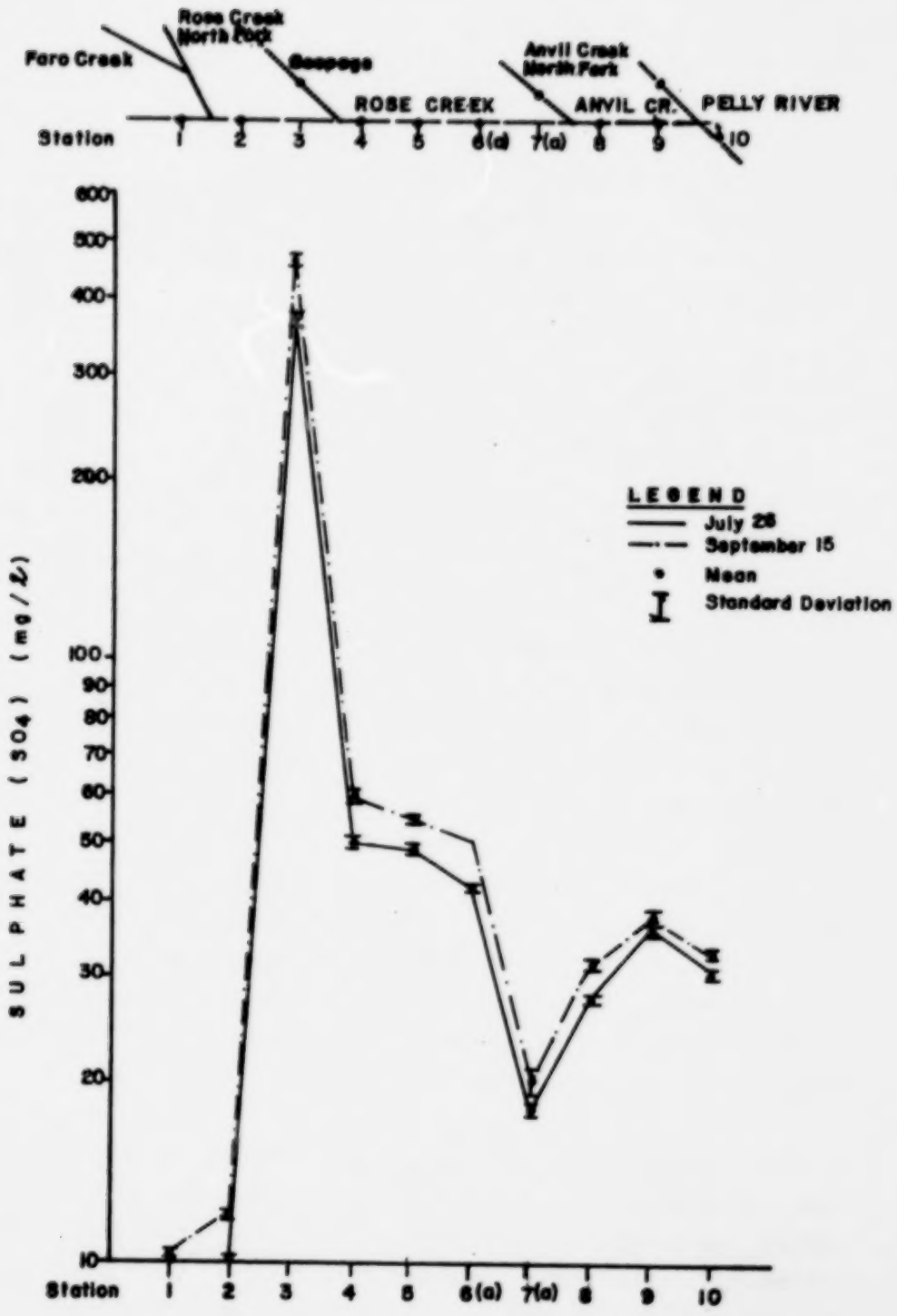


FIGURE 8 MEAN VALUES OF SULPHATES IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

molydenum (Mo), antimony (Sb), selenium (Se), tin (Sn), and vanadium (V) values were below the EPS Laboratory detection limit for that element. Arsenic (As), boron (B), barium (Ba), nickel (Ni), lead (Pb), silica (Si) and titanium (Ti) levels were over the detection limit but below acceptable levels for drinking water and for aquatic life. These metals showed little fluctuation spatially and temporally along the creek, suggesting no impact from the mine.

Calcium (Ca), potassium (K), magnesium (Mg) and strontium (Sr) values were all less than the acceptable level for the protection of aquatic life. Seepage at Station 3 contained levels of these metals which exceeded Rose Creek (Station 1) by 3 to 6 times. Levels of these metals at Station 4 (Rose Creek) and further downstream, were lower than the seepage (Station 3) values but remained elevated over Station 1, indicating the influence of the seepage. This increase may be due to the input of those elements by erosion because comparable levels of metal exist in Anvil Creek at Station 7(a).

Manganese (Mn) and sodium (Na) at Station 3(seepage) were from 40 times to 150 times higher than the background levels measured at Stations 1 and 2 (Rose Creek). Associated dilution decreased Station 3 seepage level effect in Rose Creek (Station 6) to a value which remained marginally higher than Station 7(a) Anvil Creek.

Iron (Fe) and aluminum (Al) showed variation without pattern. Iron (Fe) levels increased 8 times at Station 3 (seepage) between sample dates but this is not seen at any other location. The aluminum (Al) at Station 7(a) (Anvil Creek) exceeds the recommended level for aquatic life as outlined by Health and Welfare Canada, on September 15, 1983, but was the only sample to do so.

4.2.2 Copper. The level of copper differs notably between the sampling dates (Figure 9). All samples collected on July 26, 1983 had copper levels below the recommended level for aquatic life while on September 15, all samples exceeded this level of 0.0050 mg/l. Demayo and Taylor (1981) suggest a limit of copper of 0.0020 mg/l total in water but also mention that existing levels and effects of local water

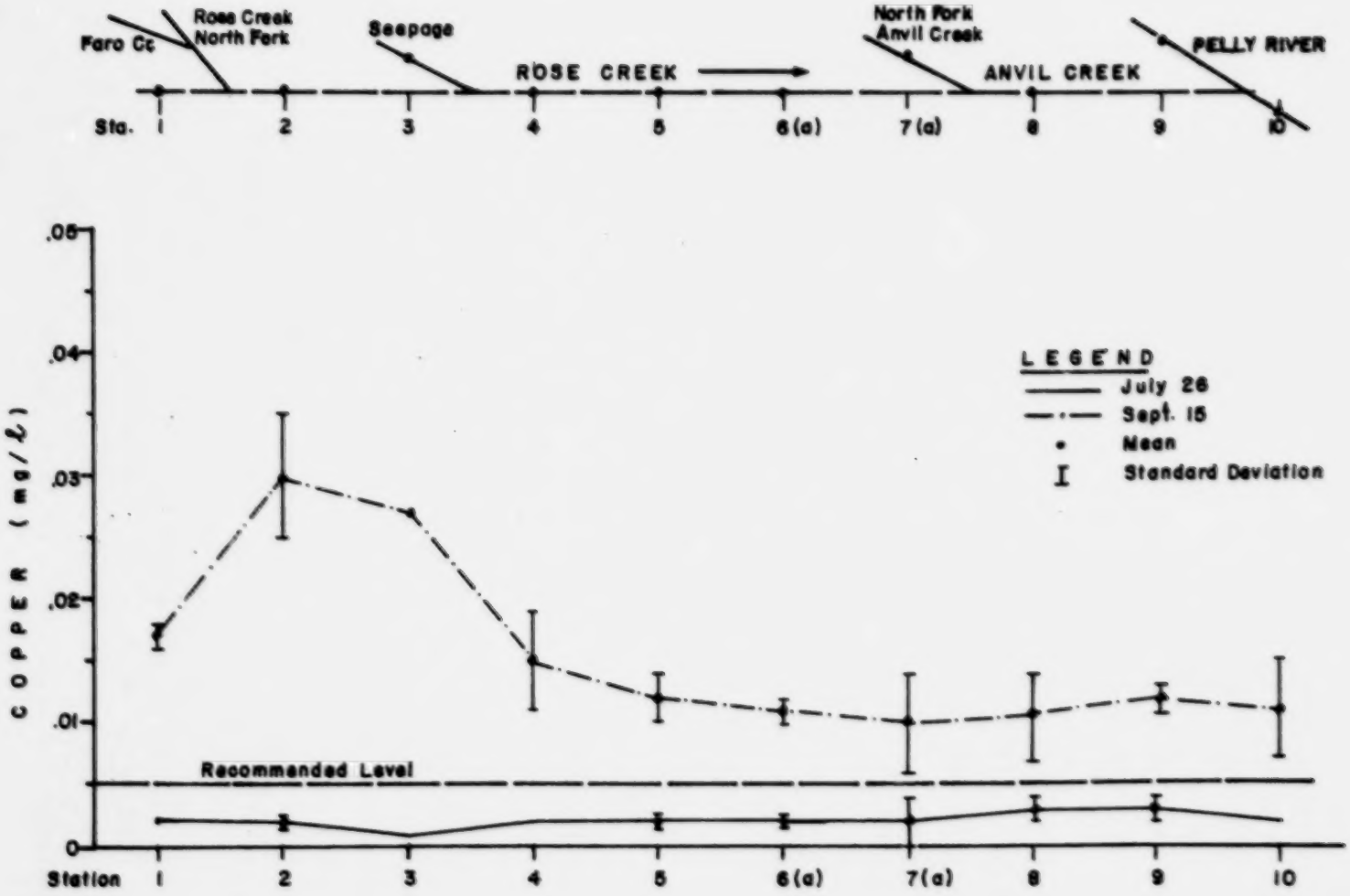


FIGURE 9 MEAN VALUES OF EXTRACTABLE COPPER IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983.

quality must be taken into account when setting an objective for copper for specific bodies of water. The Yukon Territory Water Board require Cyprus Anvil to meet a level of 0.20 mg/l (extractable) for copper in the effluent discharge. Station 3 (seepage) exceeded this requirement on September 26, 1983.

According to Nriague (Demayo and Taylor 1981), approximately 25% of the copper is from natural sources (windblown dusts, vegetation exudates, volcanic emissions, sea salt spray) and the rest is from anthropogenic sources. In an intensive study of Susquehanna River by Troup and Bricker (Demayo and Taylor, 1981) it was found that the total metal concentrations (Mn, Fe, Cd, Cr, Co, Cu, Ni and Zn) were correlated with the discharge of the river and with the total suspended solids, thus in a period of high discharge, most of the metals were carried in the suspended solids phase. Another study by Jennett et al (Demayo and Taylor, 1981) monitoring the water quality of a region of mining and milling, found that during peak runoff periods following a storm, dissolved metal concentrations increased abruptly and suspended solids increased signficantly. The concentration of copper in the water may also increase by the formation of copper complexes. The increase of organic acid concentration derived from complexing also results in increases of pH (Bolter and Butz, 1975, quote in Demayo and Taylor, 1981).

The analysis performed on our water quality is for extractable metal which include the dissolved metals, the absorbed metal on small inorganic particles and the organic complex which are digested by the acid. The highest peak recorded in September is at Station 2 (Rose Creek) which drains the northeast side of the mine property. Significant increases in Copper (Cu) levels at Station 1 (Rose Creek Control Station) may be attributable to the high flows in September.

Previous data on Rose Creek (Hoos 1973, Baker 1979, Weagle 1981) for extractable copper shows levels only at the detection limit of 0.01 mg/l, which is still twice the recommended level for safe aquatic life (Thurston et al, 1979). Generally, downstream stations in September had levels twice the detection limit of earlier studies. In

1978, significantly higher (6-7 times) copper (Cu) levels were recorded in Rose Creek (Baker, 1979). In July, copper (Cu) levels are below acceptable for drinking water (1.0 mg/l) at all stations.

4.2.3 Zinc. The levels of extractable zinc in the water were all close to or higher than the EPA recommended level for aquatic life of 0.030 mg/l (Thurston et al, 1979), except Station 3 (Seepage) on July 26 which was 0.0020 mg/l (Figure 10). DeMayo and Taylor (1981) suggest different acceptable levels of zinc based on the hardness classifications given in the Hydrological Atlas of Canada 1978. For a hardness as mg/l $CaCO_3$ 0 to 120, the maximum acceptable level of total zinc is 0.050 mg/l; hardness 120-180, the level is 0.10 mg/l of zinc; hardness 180-300, 0.2 mg/l zinc and over 300 the zinc level may be up to 0.30 mg/l.

The distribution of zinc in the water throughout Rose Creek, follows similar patterns as copper (Cu). September levels of zinc exceeded both recommended EPA and Health and Welfare Canada levels except Station 3 (seepage) which, because of hardness (300 mg/l), did not exceed the Canadian guideline. Zinc levels of upstreams stations are high in the fall and it may be caused by high flows increasing erosion into the stream. The values observed at Station 2 (Rose Creek) which were the highest value recorded in this study, are attributed to the drainage of the east part of the mine by the the north fork of Rose Creek. The water licence issued by the Yukon Territory Water Board, identifies the maximum level of zinc permitted in the effluent to be 0.50 mg/l zinc (extractable). All stations fell within this requirement.

Demayo and Taylor (1981) suggested that in case of high natural levels, the objectives for safe aquatic life should meet the natural level.

The background levels of zinc (Station 1) have increased since the baseline study was completed in 1973. At that time zinc (Zn) showed less than 0.010 mg/l as total zinc (Hoos, 1973). In 1974, background levels increased to a mean of 0.275 mg/l $\pm$ 0.5

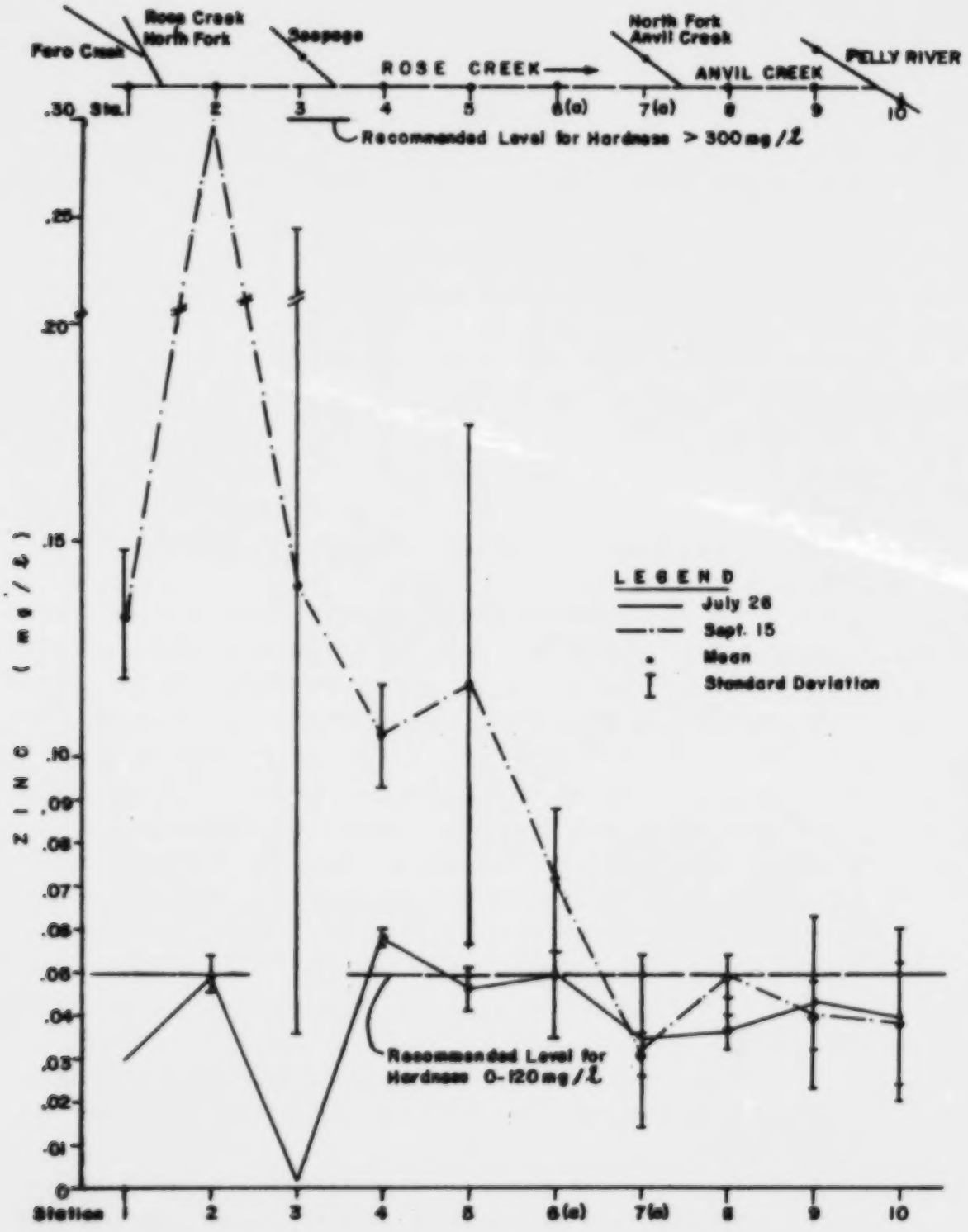


FIGURE 10 MEAN VALUES OF EXTRACTABLE ZINC IN WATER SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

giving an idea of the variability of the zinc content at that station. During the following years (Baker 1979, Weagle 1981), zinc (Zn) content stabilized at 0.10 mg/1. Zinc levels decreased from Station 4 (Rose Creek) highs as further dilutions occured towards downstream stations. The downstream level in previous years, are quite similar to what we see in our present study (Baker 1979, Weagel 1981). Zinc (Zn) levels at downstream stations from this study are similar to previous studies (Baker 1979, Weagle 1981).

4.3 Sediment

4.3.1 Particle Size Analysis. Results of the particle size analysis are shown in Appendix III, Table 1. When analyzing and discussing the results of sediment analysis, it is necessary to be aware of the variability that can occur among replicate samples due to natural variation in the streambed composition.

Results show a high percentage of gravel except at Station 7(a) (Anvil Creek) and 10 (Pelly River), at which fine sand and silt are predominant. When sediment samples were collected, all material larger than 32mm (pebbles) was selectively removed by hand and discarded. Therefore, the particle size distribution data must be handled with caution.

Particle size affects leachable metals results and the benthic invertebrate distribution and abundance (to be discussed in following sections). Only that portion of sediment smaller than 149 um was analysed for leachable metals since these particles can adsorb more metals on the surface which affect the aquatic environment.

4.3.2. Sediment Metal Analysis. The results of analysis for metals levels in the sediments are presented in Appendix III Table 2.

The metals analysis shows variability in the results. Only cadmium (Cd), molybdenum (Mo), silicon (Si), and titanium (Ti) show significant changes between sample dates ($p<0.05$) using Student's

t-distribution. Cadmium (Cd) and silicon (Si) are higher in July while molybdenum (Mo) and titanium (Ti) are higher in September at Station 4 (Rose Creek). Other significant differences occur at Stations 3 (seepage) and 8 (Anvil Creek) but cannot be tied into an obvious pattern (Figure 11).

An overall view of the leachable metal concentrations in the sediments exhibit a general trend of increase from lows at Station 1 to highs at Stations 4, 5 and 6(a) (Rose Creek) followed by a decrease to Station 10 (Pelly River). This particular increase in heavy metals (Ag, As, Ba, Cu, Fe, Hg, Mo, Pb, Zn) at middle stations on Rose Creek (Figure 12), may be explained by the remaining effects of a tailings pond spill in March 1975, when 2.45×10^5 m^3 of tailings slurry contaminated Rose Creek. In 1975, the slurrys were seen up to the confluence of Rose Creek and Anvil Creek. The cadmium (Cd) results for September did not follow this general increase/decrease trend.

The present study results show copper (Cu), zinc (Zn), arsenic (As) and Barium (Ba) to have higher levels present at middle stations (Stations 4 and 5) than existed in 1973 (Hoos, 1973). The 1973 detection limits were too high for comparative assessment of cadmium (Cd) with results from this study.

4.4 Bottom Fauna

The use of the benthic invertebrates as indicators of stream quality is guided by some biological considerations. Invertebrates have relatively low mobility which reflect conditions of that particular location. In stream pollution, the variability of contaminant discharges can be integrated by the benthic community and give an idea of pollution over an extended period, which is not the case with water grab samples.

4.4.1 Artificial Substrate Sampler. The artificial substrate sampler allows collection of data from locations that cannot be sampled effectively by other methods. It eliminates subjectivity of choice and

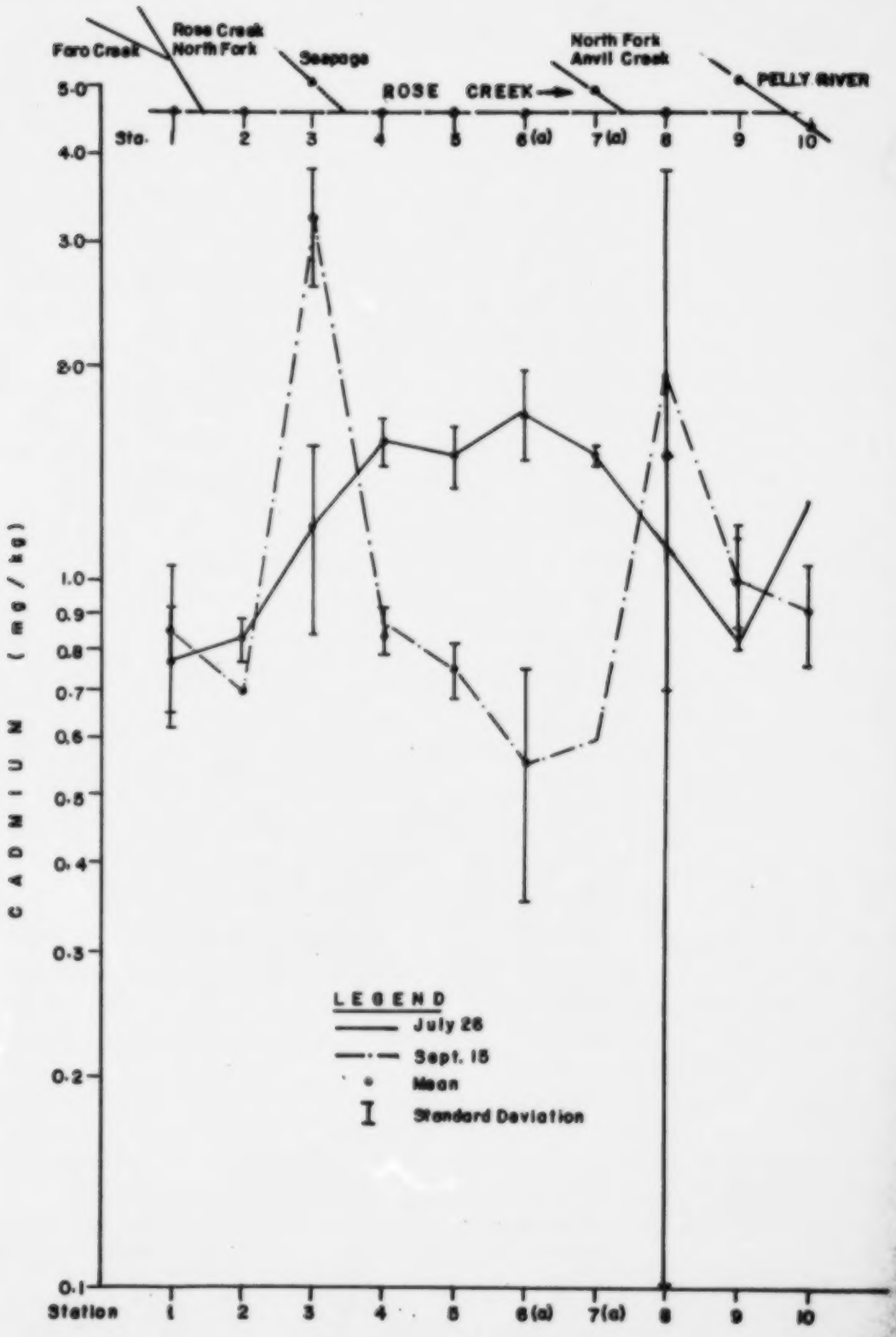


FIGURE 11 MEAN VALUES OF EXTRACTABLE CADMIUM IN SEDIMENT SAMPLES COLLECTED ON JULY 26 AND SEPT. 15, 1983

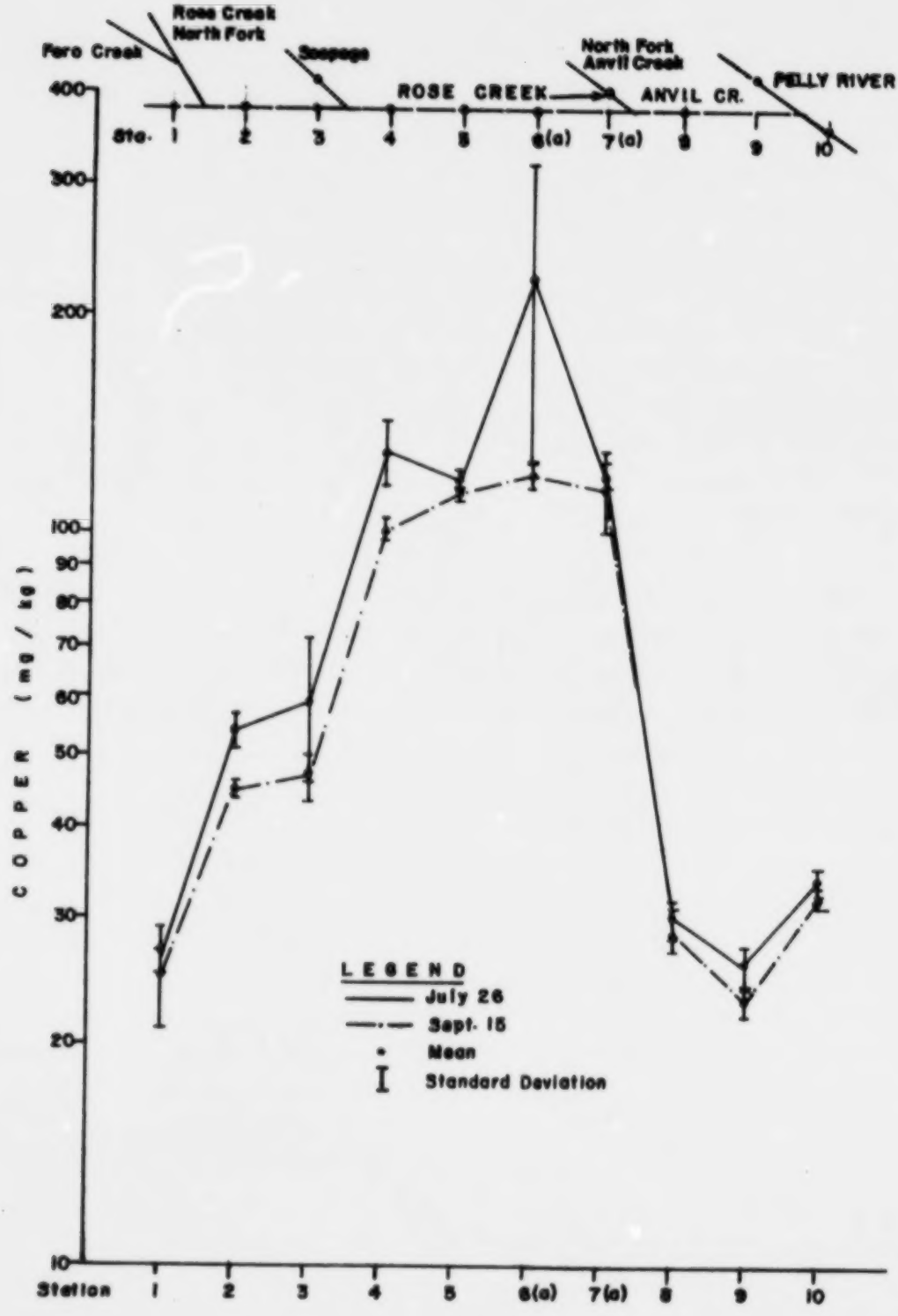


FIGURE 12 MEAN VALUES OF EXTRACTABLE COPPER IN SEDIMENT SAMPLES COLLECTED ON JULY 26 AND SEPTEMBER 15, 1983

sampling at a number of different stations, reducing confounding effects of differences in habitat substrate, depth and time (Rosenberg and Resh 1982). The variability in replicates using the artificial substrate sampler is reduced compared with other types of sampling methods (Khalaf and Tachet 1978, Rosenberg and Resh 1982).

EPS (unpublished data) has experimented with the artificial substrate sampler to determine the sampling effectiveness and the number of replicates required to obtain an adequate sample. The results of this work with this type of sampler indicates that 3 replicates are required to obtain an adequate sampling to represent the community.

The samplers were retrieved after 50 days colonization time. The samplers at Station 8 could not be retrieved on September 15, 1983 due to the high water conditions and fast current. Station 3, due to low water levels could not meet the requirement of depth, current and texture of substrate particles. All substrate particles were completely covered with ferrous (Fe) precipitate at Station 3 (seepage) and for this reason, Station 3 can be considered as atypical in the sampling program.

4.4.2. Taxonomic Features. The taxonomic levels involved in the discussion may refer to the class, order, family or genus. Organisms which are rare and are not well represented are referred to at the class level. Class Insecta had the greatest variety of organisms present. Separation of Class Insecta into orders is usually based on functional morphology structures. The Diptera were too diverse to specifically comment on at that taxonomic level and so were analysed at the family level. Comparisons between specific organisms was dealt with at the genus level.

A total of 32,994 organisms were collected from the 9 stations (substrate samplers were lost at Station 8). They comprised 71 different taxa, of which 51 are at the genus level. A taxonomic list of the benthic invertebrates collected during the survey on September 15, 1983 is given in Appendix IV, Table 1. The complete

description of the numbers and percentage abundance of organisms sampled at each station and their relative density per cubic meter is found in Appendix IV, Table 2. Appendix IV, Table 3 provides a summary comparison of diversity indices for benthic invertebrate data from previous studies, including monitoring programs sponsored by CAMC.

The greatest numbers of genera are found at Station 1 with 41 genera, followed by Stations 10, 5 and 4 with 37, 32 and 31 genera respectively. The lowest number of genera, 17, occured at Station 3.

The abundance varies from station to station. The greatest abundance can be found at Station 10 with 7407 organisms (433,158 organisms per metre^3). Stations 4 and 5 had 5187 (303,333 organisms per m^3) and 5436 (317,895 organisms per m^3) organisms respectively. The lowest number of organisms is found at Station 7a (Anvil Creek) with only 2094 individuals (122,456 organisms per m^3). The low abundance of individuals at Station 7a partially caused by a loss of rock substrate from one of the 3 replicate artificial substrate sampler which broke open during the survey. Only a quarter of the basket was filled at time of retrieval.

The two dominant genera are Capnia sp (Plecoptera) and Baetis sp (Ephemeroptera). Both are found at all stations and represent 18.5% and 17.6% respectively of the total organisms encountered at the genus level.

Seven genera were present at all stations of which three are representatives of the order Plecoptera, one in the order Ephemeroptera and three in the Family Chironomidae. Seven other genera, three in the order Plecoptera, two in the order Ephemeroptera, one in the order Trichoptera and one in the family Simuliidae were present (Table 3) at all stations except Station 3 (seepage). Table 4 lists the percentage composition of major taxa at each station.

The percentage dissolved oxygen (%DO) present at Station 3 (seepage) during the two surveys is below 40% saturation. The nymphal stage of the Plecoptera are typically found in water with a relatively high oxygen content (Wetzel, 1975), and would account for a very low representation of Plecoptera in the seepage from the Cross Valley Dam

(Station 3). The high percentage composition of Plecoptera at Stations 9 and 10 cannot be explained only by the oxygen levels. The use of an artificial substrate sampler may provide a better habitat for the Plecoptera than for other groups therefore their density relative to other groups increases.

The Ephemeroptera (mayflies) also require high levels of dissolved oxygen for optimum development and their percentage composition is also very low at Station 3. Sprague et al (Winner, 1980) indicates that mayflies are sensitive to copper and zinc. Cairns and Dickson (1971) consider the Ephemeroptera as a pollution sensitive group. The results of the present study indicate that the distribution of the Ephemeroptera does not seem to be influenced by the levels of extractable zinc and copper present in the water. Station 2, had the highest zinc and copper levels and was also the station at which all the genera of Ephemeroptera found in the survey were represented. Wetzel (1972) indicates that substrate type and specific sediment particle size may restrict species distribution. Khalaf and Tachet (1980) have shown that the Ephemeroptera is the only order of aquatic insects that show differences in numbers recovered using the artificial substrate sampler. The texture of the rocks and substrate, as well as the low dissolved oxygen levels at Station 3 (seepage) may partially explain the poor representation of Ephemeroptera.

The Trichoptera sampled at all stations were few, with a mean percentage composition of 2.07% . Station 6(a)(Rose Creek) shows the highest percentage (10.94%) of order Trichoptera and station 3 (seepage) the lowest (0.04%). The percentage at Station 6(a) is due mainly to the presence of an Hydropsychidae, Arctopsyche sp., which constitutes 9.53% of the population at that station.

Although the Chironomids (Family Chronomidae) represent 87% of the population at Station 3 (seepage), no common chironomid genera were particularly dominant. The two major genera involved in the population are Brillia sp. (48%) and Phaenopsectra sp. (29%), both of which are well represented only at Station 3 (seepage). This and other data supports the diversity of tolerances of species within the family.

TABLE 3 GENUS PRESENCE OF BENTHIC INVERTEBRATES AT THE VARIOUS STATIONS

A. Present at all the stations

GENUS	ORDER OR FAMILY
Capnia sp	Plecoptera
Zapada sp	Plecoptera
Brachyptera sp	Plecoptera
Baetis sp	Ephemeroptera
Cardiocladius sp	Chironomidae
Cricotopus sp	Chrionomidae
Heterotrissocladius sp	Chironomidae

B. Present at all stations except Station 3

GENUS	ORDER OR FAMILY
Amphinemura sp	Plecoptera
Prostata sp	Plecoptera
Isoperia sp	Plecoptera
Ephemerella sp	Ephemeroptera
Cinygmula sp	Ephemeroptera
Brachycentrus sp	Trichoptera
Prosimulium sp	Simuliidae

C. Unique to Station 1

GENUS	CLASS OR ORDER OR FAMILY
Hydra sp	Hydroida
Paranais sp	Oligochaeta
Corynoneura sp	Chironomidae
Lymnaeea sp	Gastropoda
Valvata sp	Gastropoda
Pisidium sp	Pelecypoda

D. Unique to Station 10

GENUS	ORDER OR FAMILY
Lepidostoma sp	Trichoptera
Onocosmoecus sp	Trichoptera
Paralauterborniella sp	Chironomidae

TABLE 4 PERCENTAGE OF DIFFERENT TAXONOMIC GROUPS REPRESENTED AT EACH STATION

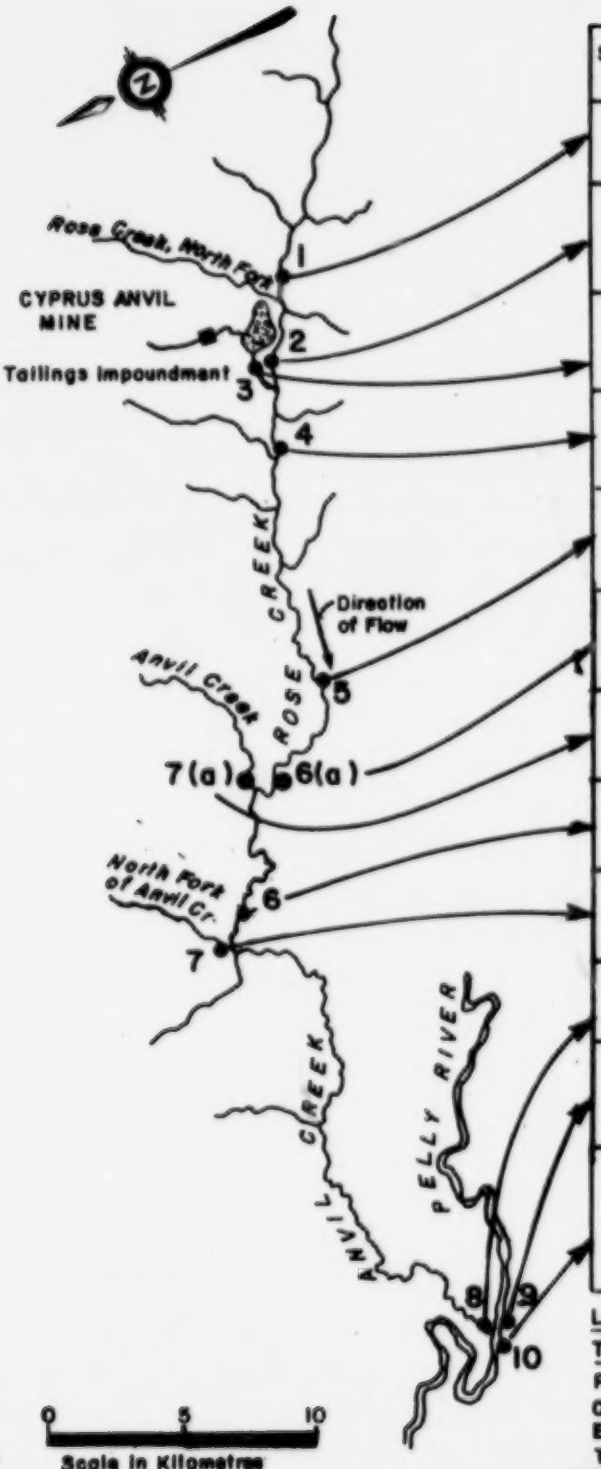
	STATION								
	1	2	3	4	5	6(a)	7(a)	9	10
Plecoptera	16.28	39.98	0.31	41.43	24.27	42.44	21.59	52.17	62.87
Ephemeroptera	25.86	25.26	0.18	36.34	42.17	37.67	41.87	17.74	3.29
Trichoptera	0.4	0.15	0.04	0.94	0.73	10.94	2.95	0.44	2.10
Chironomidae	52.38	9.43	86.81	12.54	10.38	3.94	30.34	27.07	30.83
TOTALS	94.92	74.82	87.34	91.25	78.55	94.99	96.75	97.42	99.09

Another apparent example of the specificity of habitats occupied by genera is the presence of Corynoneura sp. at Station 1 (Rose Creek) only. Lenat (1983), showed that moderately stressed streams present an ideal environment for small grazing chironomids in that algal food and refugia are abundant and the density of competitors, especially Plecoptera, Trichoptera, Ephemeroptera and Gastropoda may be reduced. Chironomids found in stressed environments usually have a very short life cycle and are capable of quick colonization and exploitation of disturbed areas subjected to recurring acute toxicity. If pollution becomes severe, the chironomid richness will decrease so a direct correlation between pollution and chironomid populations cannot be made (Lenat, 1983).

The unique genera found at Stations 1 (Rose Creek) and 10 (Pelly River) generally represent a percentage lower than 1%. Phylum Coelenterata, Class Gastropoda and order Pelecypoda are only found at Station 1 (Rose Creek). Hydra seems to be common in ponds and very clear water (Meglitsch 1972) and Pisidium seems to be a good indicator of a copper stressed region (Winner et al 1980). Phillips (1977) argues that the bivalve molluscs as well as the macro-algae constitute the best indicators of heavy metals pollution.

A comparison of the taxonomic group dominance from data at and downstream of the Cyprus Anvil mine area, show a reduction of the dominance held by the Chironomidae in downstream areas. In 1974 the Chironomidae were dominant as far downstream as Station 6 (Anvil Creek) In 1974 and 1976, the dominance of chironomids was still visible but only to Station 4 (Rose Creek) and in 1983 such dominance disappeared even at Station 4 (Figure 13). The dominance by the chironomidae in Rose Creek is presently only found at Station 1 (control station) and at Station 3 (seepage from ponds).

4.4.3 Diversity Index. The diversity index permits summarization of large amount of information about the numbers and kinds of organisms. The ecological basis for the diversity indices is that in a polluted area small numbers of species are found with large numbers of individuals, while in clear waters small numbers of individuals and many different species are found (Wilhm, 1970). The diversity is affected by several



STATION NO.	1974	1975	1976	1983
1	PC	CPE	PC	CPE
2	No Sample	No Sample	No Sample	PEC
3	No Sample	No Sample	No Sample	C
4	CPE	CPE	CPE	PEC
5	CPE	PC	PC	EPC
6(a)	No Sample	No Sample	No Sample	PET
7(a)	No Sample	No Sample	No Sample	ECP
6	CPE	PC	PC	No Sample
7	ECP	PCE	PCE	No Sample
8	PC	PCE	PCE	No Sample
9	PEC	PCE	PCE	PCE
10	PC	PCE	PCE	PC

LEGEND

Taxonomic Group

P - Plecoptera
C - Chironomidae
E - Ephemeroptera
T - Trichoptera

Indicates Chironomidae dominace

FIGURE 13 INVERTEBRATE TAXONOMIC GROUP DOMINANCE IN CYPRUS ANVIL MINE STUDY AREA

factors other than pollution and great emphasis of consistency in sampling must be shown (Hugues 1978). Depth and duration of sampling seem not to affect the diversity value but sample size, season and taxonomic level used in calculations, may change the values (Resh and Unzicher 1975).

The diversity indices calculated in this study show a peak at Station 1 (Rose Creek) with 1.07 and a second peak downstream at Station 6(a) (Rose Creek) and 7(a) (Anvil Creek) with 1.02 and 1.03 respectively. The lowest diversity was found at Station 10 (Pelly River) with 0.59 and at Station 3 (seepage) with 0.60 and both have a low evenness of 0.38 and 0.49 respectively. The diversity index at Station 10 (Pelly River) is low if compared to the density and number of species. The effect of Capnia sp. (60% of the population) on the diversity is obvious. At Station 3 (seepage), the low number of species as well as the low number of individuals present, is a reflection of the high mineral and lower content of dissolved oxygen (DO) of the groundwater seepage at that station.

The index values of diversity at most stations are higher than in the previous years as shown in Table 5 indicating an improvement in the benthic invertebrate community since the mine operation has shut down. These results must be taken with reservation because of the variation in bottom fauna collection methodology of this study and previous others. Perkins (1983) has demonstrated that inconsistency of the results of the diversity indices is subject to variability due to differences in concentrations of copper and proposes community comparison indices as an alternative.

4.4.4 Community Index. The community index used in this report is calculated as the percent similarity index (Psc). The Psc is not as sensitive to rare species and weight differences in more dominant species (Brock 1977). The Psc can detect subtle shifts in community composition which can indicate long term trends of change. Table 6 shows the similarity index matrix for the 1983 monitoring program. Station 2 (Rose Creek) shows good similarity with Stations 4 and 5

TABLE 5 COMPARISON OF DIVERSITY INDICES FOR SAMPLE STATIONS SINCE 1973

STATION	1973(a)	1974(b)	1975(b)	1976(b)	1977(c)	1980(d)	1981(e)	1982(f)	1983
1	0.69	0.64	0.64	0.76	0.76	1.21	0.97	1.14	1.07
2	-	-	-	-	-	-	-	-	0.93
3	0.71	-	-	-	-	-	-	-	0.60
4	-	0.50	0.15	0.67	0.34	0.68	0.64	0.81	0.93
5	0.48	0.38	0.39	0.84	0.88	0.44	0.78	-	0.87
6	0.78	0.60	0.27	0.85	0.79	0.58	0.70	0.52	-
1983 EPS 6	-	-	-	-	-	-	-	-	1.02
7	0.82	0.47	0.69	0.74	0.78	-	-	-	-
1983 EPS 7	-	-	-	-	-	-	-	-	1.03
7a*	-	-	-	-	-	1.01	0.80	0.70	-
8	0.57	0.45	0.23	0.52	0.96	-	-	-	-
9	0.35	0.65	0.87	0.78	0.79	-	-	-	0.88
10	0.22	0.25	0.54	-	0.96	-	-	-	0.59

(a) Hoos,R.A.W. and Holman, W.N. (1973) - Surber Sampler
(b) Baker, S.A. (1979) - Artificial substrate sampler baskets
(c) Weagle, K. (1981) - Artificial substrate sampler baskets
(d) Weagle, K. (1980) - Artificial substrate sampler baskets
(e) Weaige, K. (1981a) - Artificial substrate sampler baskets
(f) Weagle, K. (1982) - Artificial substrate sampler baskets
1983 - Artificial substrate sampler baskets

*Station just below the confluence of Anvil Creek and Rose Creek.

(Rose Creek). Stations 4, 5, 6(a) (Rose Creek) and 7(a) (Anvil Creek) show a good interstation degree of similarity (all are over 50%). Stations 9 and 10 on the Pelly River show a high degree of similarity in their benthic community (73%). Station 1 (Rose Creek), does not show a high degree of similarity with any of the downstream stations and is most similar to Station 7(a) (Anvil Creek), another station not effected by the mine site. Station 3 (seepage), which has distinctive water quality characteristics and a different chemical substrate composition, possesses a community structure with very little simiarity to other stations.

4.5 Biota-Algae

The results of the analysis for extractable metals are shown in Appendix V, Table 1. Both wet and dry weight are given, however the analysis is based on the dry weight concentration to facilitate comparisons. The results involve a single sample on July 26, 1983 and a mean composed of three samples on September 15, 1983.

The single aglae sample for July possesses metal levels (Cadmiun (Cd), Zinc (Zn), Calcium (Ca), Nickel .Ni), Lead (Pb), Strontium (Sr), Vanadium (V) and Arsenic (As)) generally higher than the mean of the replicate samples collected in September.

The observed differences in extractable metals concentrations between July and September may be due to the age of the algae and the duration of exposure to the metals (Foster 1982, Phillips, 1977). In September the age of the algae was known to be less than 50 days because the samples were collected from the surface of the artificial substrate sampler which had been deposited 50 days previously. The age of the colonies collected in July is unknown but presumed to be older. Attempts to rinse sediment from the algal mat was made for the July samples but no such attempts were made for the September samples. The accumulation rate of heavy metals also seemed to increase inversely proportional to the temperature (Phillips, 1977). The co-existence of several heavy metals that compete for binding sites may change the

TABLE 6 THE PERCENT SIMILARITY INDEX MATRIX FOR THE 1983 MONITORING PROGRAM

STATION	2	3	4	5	6(a)	7(a)	9	10
1	36.24	10.95	43.19	40.99	39.81	46.12	40.34	20.05
2		4.24	58.32	67.15	45.25	40.60	23.21	10.84
3			3.00	12.25	11.91	2.65	2.97	3.65
4				77.75	71.02	62.23	24.53	11.11
5					55.14	50.43	22.28	11.08
6(a)						63.91	37.47	27.87
7(a)							42.64	37.59
9								73.09

uptake of an element due to the presence of a competitor metal and lead to different heavy metals levels in the algae (Phillips, 1977). For the above reasons, it is not possible to draw conclusions using the algae present as an bio-indicator of the habitat conditions due to the effect of environmental variables.

Establishing a relationship between the algae found (class Bacillariophyceae) and the environmental conditions is difficult. Foster (1982) indicates that algal diversity as measured by the number of species and their relative abundance appeared to be reduced by metal pollution, particularly at sites high in copper (Cu) and zinc (Zn). An experiment by Januszko (DeMayo and Taylor, 1981) with members of the Bacillariophyceae showed an increase of biomass from 27 g/m^3 of algae in copper treated ponds. No analysis of the periphyton community from these aspects was performed during the present study. The algae sample collected at Station 3 (seepage) was present in large quantities and maybe one species specifically adapted to exploit the unique conditions that exist at Station 3 (seepage).

4.6 Bioassay

The results of the bioassay performed on the Cyprus Anvil tailings pond seepage (Station 3) and Rose Creek control station (Station 1) are shown in Table 7.

The Daphnia pulex acute toxicity test performed on the control station ran for 48 hours and for 96 hours on the seepage samples. Both show an LC_{50}>100%.

Experimental threshold concentration using Daphnia magna with various metal ions (Biesinger and Christensen, 1972) indicates that our metal effluent concentrations were always below the 48h-LC_{50} determined. The response of Daphnia pulex and Daphnia magna is assumed to be approximately the same under similar conditions.

The control dilution (0% treatment) had one death per test which falls well within acceptable limits to validate the test, which allows up to 20% mortality in the control (DOE, 1980).

Considering those aspects of the test, the seepage water from Station 3 on July 26, 1983 is considered of very low toxicity under the test conditions and parameters of this bioassay.

5 ENVIRONMENTAL COMPLIANCE MONITORING

5.1 Regulatory Requirements of the Cyprus Anvil Mine

The mine discharges a 'waste' within the meaning of the Northern Inland Waters Act and is required by that act to hold a water licence. In addition, certain provisions of the Fisheries Act, in particular the Metal Mining Liquid Effluent Regulations, apply to the mine's operation. Thus the mine may not discharge an effluent containing concentrations in excess of those stated in the regulations or prescribed in the licence granted by the Yukon Territory Water Board.

Water licences are obtained through application to the Yukon Territory Water Board and public hearings into each application are customary. The Board may attach conditions to any licence and among these are requirements for wastewater treatment and compliance monitoring. In March 1982, the Yukon Territory Water Board conducted a public hearing at Faro, Y.T., to consider the company's plans to utilize a new tailings facility and to amend its licence. Subsequent to granting the amendment, the Water Board required the company to collect water samples on a routine basis at the stations plotted in Figure 3 and listed in Table 3.

5.2 Monitoring Data 1974-1983

Appendix VI, Tables 1a, 1b and 1c, show historical water quality results for compliance monitoring sites X-3, X-14 and X-15 respectively as compiled from information in government files and consultants' reports. Station X-3 corresponds approximately to 1983 EPS Station 1 (see Table 1). Licence Station X-14 is comparable to Station 4, while licence Station X-15 is comparable to Station 4. Station X-14 when compared to Station X-3 shows an increase in the comparable parameters Ca, Mg, Mn, Na and SO_4 downstream, that is, within the influence of discharges from the mine. These discharges have been mainly

through seepages below the final or cross valley tailings dam in the long period since the mine curtailed production in June 1982, but they include surface discharges at X-5, or through large siphons. Thus the mine has had a measurable effect on receiving water quality in Rose Creek for many years and the results of the present study (Section 4) support a long-term trend.

Table 8 compiles Zn, Pb and Na values for selected compliance monitoring stations on the mine's property during the June 1982 - December 1983 period. Stations X-7, X-22 and X-23 show elevated values for Pb and Zn reflecting discharges to the tailings pond systems. The main pit has been pumped continuously throughout the study period. This water at point X-22 seeps through oxidized sulphide waste rock to emerge at X-23. Downstream this flow is diluted by scavenging and circulating water discharged from the mill complex, and by natural runoff. Station X-7 data reflects the quality of the combined flows - pit pumpings, mill water and natural drainage - passing into the tailings area and the first large pond.

Flows passing over and through the old tailings areas are joined by natural groundwater flows to determine the quality of water in the large intermediate dam pond. Table 9 presents values for zinc and pH at the decant of the intermediate dam (X-4) and other stations. An average value of 1.58 mg/l for zinc at X-4 compared to 12.99 mg/l at X-7 shows that either the zinc content seen at X-7 has been reduced by some filtering process in passing through the tailings or there is an eight-fold dilution of X-7 flows from other sources flowing into the intermediate dam pond. Since the decant from this pond forms only a small portion of the flow into the cross valley pond, it is reasonable to assume that filtration under the intermediate dam is effective in reducing zinc levels to those seen at X-5, or at the equivalent stations S-8, 8 inch siphon, and S-16, 16 inch siphon. Thus the system comprising two large ponds and filtration has enabled high zinc pit pumpings to be treated to levels suitable for discharge.

Table 9 presents linear correlations between zinc concentration and pH. Significant correlations of between -0.72 to -0.86 appear

TABLE 7 *Daphnia pulex* BIOASSAY RESULTS OF CYPRUS ANVIL TAILING POND SEEPAGE

Acute Toxicity Tests

Water sampled July 26, 1983 at Station 1 (control)
Bioassay started August 3 at 11:30 AM.

Fifty percent lethal concentration
48 h - LC_{50} = >100%

CONCENTRATION	BEFORE TEST		TIME (hours)				
			T=0	T=2	T=4	T=24	T=48
	pH	DO (ppm)	11:30	13:30	15:30	11:30	11:30
Control 0% Solution	8.05	8.0	10	10	10	10	9
20% Solution	8.05	8.0	10	9	9	9	9
40% Solution	8.05	8.0	10	10	10	10	10
60% Solution	8.05	8.0	10	10	10	10	10
80% Solution	8.05	8.0	10	10	10	9	8
100% Solution	8.05	8.0	10	10	10	10	10

Water sampled July 26, 1983 at Station 3 (seepage)
Bioassay started July 28 at 11:30 AM.

Fifty percent lethal concentration
96 h - LC_{50} = >100%

CONCENTRATION	BEFORE TEST		TIME (hours)				
			T=0	T=2	T=4	T=24	T=96
	pH	DO (ppm)	11:00	13:00	15:00	11:00	11:00
Control 0% Effluent	8.14	7.6	10	10	10	9	9
20% Effluent	8.14	7.6	10	10	10	9	8
40% Effluent	8.14	7.6	10	10	10	9	9
60% Effluent	8.14	7.6	10	9	9	7	7
80% Effluent	8.14	7.6	10	10	8	7	7
100% Effluent	8.14	7.6	10	10	9	8	8

TABLE 8 WATER QUALITY, SELECTED PARAMETERS - JUNE 1982 - DECEMBER 1983 (values extractable, mg/l)

STATION	# OF SAMPLES	LEAD				ZINC				SODIUM			
		MAX.	MIN.	AVG.	STANDARD DEVIATION	MAX.	MIN.	AVG.	STANDARD DEVIATION	MAX.	MIN.	AVG.	STANDARD DEVIATION
X-2	18	0.15	0.01	0.05	0.035	9.92	0.04	0.13	0.10	25	2	6	4.99
X-3	18	0.17	0.02	0.04	0.035	0.19	0.02	0.06	0.039	11	1	3	2.24
X-7	19	4.00	<0.01	0.23	0.26	33.9	0.28	12.99	8.52	89	2	37	26.10
X-10	18	0.08	0.01	0.04	0.021	0.43	0.03	0.12	0.11	11	1	4	2.46
X-14	18	0.07	0.01	0.04	0.019	0.36	0.01	0.10	0.096	160	3	54	47.8
X-22	14	1.05	<0.02	0.16	0.26	50.10	5.12	23.08	12.13	126	28	63	35.0
X-23	21	0.28	0.03	0.09	0.06	38.80	3.02	15.00	8.16	88	16	43	22.67

TABLE 9 COMPLIANCE MONITORING - FOR Zn and pH, 1982-83

STATION	# OF SAMPLES	Zn		pH		r Zn/pH	COMMENTS
		Mean	S.D.	Mean	S.D.		
Surface							
X-22	14	23.08	12.13	7.09	0.57	-0.4059	pumped from pit
X-23	21	15.01	8.16	6.82	0.34	-0.6263	seepage below waste rock
X-7	19	12.99	8.52	7.34	0.93	-0.2425	incl. mill waters
X-4	20	1.58	1.27	7.44	0.46	-0.7168	pond decant
S-8/S-16 (X-5)	10	0.04	0.016	7.86	0.18	-0.4778	pond decant incl. liming
X-11	19	0.07	0.05	7.38	0.20	-0.6047	seepage
X-12	19	0.07	0.036	7.47	0.20	-0.6316	seepage
X-13	21	0.05	0.027	7.52	0.33	-0.1603	seepage
Groundwater							
X-16	5	0.03	0.027	7.68	0.33	-0.5972	
X-17	9	0.04	0.034	7.67	0.17	-0.2601	
X-18	8	0.08	0.076	7.52	0.16	-0.0748	
X-21	10	0.22	0.26	7.42	0.26	-0.7773	
X-24	5	0.12	0.14	7.38	0.12	-0.8573	
X-25	5	0.07	0.044	7.42	0.098	-0.2691	

only for the pond decant X-4 and groundwater monitoring stations X-21 and X-24. This result is not easily explained since the waters are not acidic and zinc-laden flows at X-7, X-22, X-23 show generally low to poor correlation. It is suggested here that the elevated zinc content of the mine or mill discharge will be reduced linearly with an increase in some constituent of the native ground and surface waters, but only within a narrow range of zinc and pH values. Station X-21 shows that there is some zinc contamination of groundwater but it is strongly attenuated compared to surface flows.

5.3 Non-Compliance Incidents 1982-1984

After the mill curtailed production in June 1982, pumpings from the pit and mill scavenging waters containing high zinc values continued to dischage into the intermediate dam pond, which at time of shut-down was markedly basic form residual mill reagents. In August, 1982, the decant X-4 showed a zinc content of 1.55 mg/l and a pH of 6.9, and by December, the zinc had reached 4.56 mg/l. Meantime the cross valley pond water quality changed from 0.26 mg/l zinc in July to 2.06 mg/l in November. Mitigative action by the owners included sand-bagging the decant at X-5 and treating the pond with massive doses of lime to elevate the pH. It was evident that during periods of mill shut-down, control of zinc levels in the ponds through filtration and seepage required the reduction of mill discharges to the two ponds and lowering of the level of the cross valley pond. This was achieved by siphoning during 1983, and no further compliance problem occurred at that point.

A second non-compliance interval occurred in the winter months of 1983-84. Routine monitoring by the company in October, 1983, at site X-2 on the north fork of Rose Creek, showed a zinc value of 1.18 mg/l. A small seepage flow containing high zinc values was seen upstream of X-2. This seepage appeared to originate in water overtop-ping the impervious walls of Pit 2 (See Figure 3) which in turn was

caused by dumping waste rock stripped from Pit 1 into Pit 2. Control of this seepage as obtained with difficulty: elevated levels of zinc at X-2 persisted into 1984.

It is apparent that oxidation of the high sulphide ores and tailings characteristic of this mine will continue to present problems in water treatement. Mitigative measures including filtration under the dams and control of flows into the basin should succeed over the short term while mill production is curtailed. However, the long term may present a chronic problem if oxidation accelerates within the old tailings area, and if the stability of the two large tailings dams and the diversion canal deteriorates. The problem of abandonment of the site and the real potential of long term heavy metal pollution of the waters in Rose Creek remains to be addressed by the mine and the regulatory authorities.

CONCLUSION

The impact of the discharges from Cyprus Anvil mine on the aquatic environment of Rose Creek was studied in 1983. This corresponds to a period when the mill was not in operation. It was found that generally the environmental quality in Rose Creek has been improved from what had been found in previous years.

The major points found are:

1. Station 2 (diversion channel) shows an increase of concentration in extractable metals (copper and zinc) which can be attributed to the North Fork of Rose Creek;
2. Station 3 (the seepage from the tailings pond) shows a decrease of dissolved oxygen, increases of hardness, alkalinity, filterable residue, conductivity, sulfate, manganese, sodium, copper, iron and aluminum from previous studies as well as from other results in this report;
3. The sediment analysis revealed an important increase of heavy metal in the middle creek station (4, 5, 6a and 7a) for the silver, arsenic, barium, copper, iron, mercury, molybdenum, lead and zinc, which might be related to the tailings spill in 1975;
4. The bottom fauna analysis reveals an increase in the abundance of organisms sampled over previous years which was partially caused by the sampling procedures and the improvement in water quality. The benthic invertebrate analysis shows a moderate stress at Station 3, observed by a change in species composition, and decrease in diversity. The highest similarity between the stations are between (4, 5, 6a and 7a) and (9 and 10);
5. The analysis of the extractable metals in the algae shows significant differences for cadmium, zinc, nickel, lead, strontium, vanadium and arsenic, between the two surveys. It is suggested that the high concentration in July is caused by bio-accumulation;
6. Bioassays using Daphnia pulex shows no acute toxic effect due to seepage from the tailings pond (Station 3);
7. The environmental compliance monitoring of the mine shows cases of non-compliance incidents in 1982-83 indicating high levels of zinc concentrations at the tailings pond, and in 83-84 winter months at X-2 on the north fork of Rose Creek.

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APPENDICES

APPENDIX I

COLLECTION, PRESERVATION, ANALYSIS OR IDENTIFICATION METHODS AND WATER QUALITY CRITERIA

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Temperature	0.1°C	In situ temperature reading.	Standard Centigrade Thermometer	
Flow		In situ flow measurements using a Price-type current meter.	Cross-section of the stream was measured and the velocity of flow was calculated using the standard Price-type Current Meter Method[3].	
Dissolved Oxygen	1.00 mg/l	In situ measurement. The instrument was calibrated in the field under water saturated air condition.	YSI Dissolved Oxygen Meter	
pH		Small aliquots of sample were taken and read soon after collection. No preservative. Instrument was calibrated using 7.0 buffering solution.	Potentiometric	080
Conductivity	0.2 umhos/cm	In situ measurement. Laboratory measurement, specific conductivity at 25°C. No preservative. The measurement was taken from the same as NH_3 below.	YSI Conductivity Meter Model 33 Radiometer Conductivity Meter (CDMC).	044

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Ammonia NH_3-N	0.005 mg/l	Single samples collected in 2 litre linear polyethylene containers. Each container was rinsed 3 times with sample before it was filled. No preservatives. Stored at 4°C.	Phenol Hypochlorite-Colorimetric-Automated	058
Colour	5 (colour units)	Same sample as NH_3.	Platinum-Cobalt Visual Comparison	040
Turbidity	0.1 (FTU)	Same sample as NH_3.	Nephelometric Turbidity	130
Non-Filterable Residue (NFR)	5.0 mg/l	Same sample as NH_3.	Filtration, drying and weighing of residue on filter	104
Filterable Residue (FR)	10.0 mg/l	Same sample as NH_3.	Filtration, drying and weighing of filtrate	100
Total Alkalinity	1.0 mg/l as $CaCO_3$	Same sample as NH_3.	Potentiometric Titration	006
Total Phosphate T PO_4-P	0.005 mg/l	Same sample as NH_3.	Acid-persulphate, Autoclave Digestion	086
Nitrate NO_2-N	0.005 mg/l	Same sample as NH_3.	Diazotization-Colorimetric-Automated	070

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Nitrate NO_3-N	0.01 mg/l	Same sample as NH_3.	Cadmium Copper Reduction Colorimetric Automated	072
Sulphate SO_4	1.0 mg/l	Same sample as NH_3.	Barium Chloranilate -UV Spectrophotometric	122
Chloride Cl	0.5 mg/l	Same sample as NH_3.	Thiocyanate-Combined Reagent-Colorimetric	024
Extractable Metals	mg/l	Single or triplicate samples collected in 200 ml linear polyethylene bottles. Each bottle was rinsed 3 times with sample before filling. Preserved to a pH <1.5 using 2.0 ml concentrated HNO_3.	Inductively Coupled Argon Plasma	300
Al	0.05			
As	0.05			
B	0.001			
Ba	0.001			
Be	0.001			
Ca	0.050			
Cd	0.004			
Co	0.005			
Cr	0.005			
Cu	0.005			

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Extractable Metals (continued)	mg/l			
Fe	0.005			
Mg	0.10			
Mn	0.001			
Mo	0.005			
Na	0.2			
Ni	0.02			
Pb	0.04			
Sb	0.05			
Se	0.05			
Si	0.01			
Sn	0.01			
Sr	0.002			
Ti	0.002			
V	0.01			
Zn	0.002			
As	0.00050	Same sample as metals.	Hydride Generation - ICAP	350
Cd	0.0005	Same as sample metals.	Flame Atomic Absorption Spectro-photometry	330
Cu	0.001	Same sample as metals.		
Pb	0.001	Same sample as metals.		

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Ag	0.0005 mg/l	Same sample as metals.	Flame Atomatic Absorption Spectrophotometry	330
K	0.01 mg/l	Same sample as metals.	Flame Atomic Emission Spectrophotometry	340
Total Hardness	0.030 mg/l as $CaCO_3$	Same sample as metals.	The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 reported as mg/l $CaCO_3$.	

1 As described in Environment Canada (1976).

2 As described in Department of Environment (1979).

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
All Parameters	Creek and River Stations: Sediment samples were collected using an aluminum shovel to scoop sample into pre-labelled Whirl-Pak bags. Three samples were taken at each station. Samples were kept cool and were frozen (-19°C) as soon as possible.		
Mercury Hg (Total)	Sample was freeze-dried for 48 hours to remove water. Sample was sieved through a size 100 mesh (.15 mm) stainless steel sieve. The portion passing through was analyzed for mercury. Sample was completely oxidized by digestion with H_2SO_4 and H_2O_2.	Mercury Monitor	370
Metals (Leachable) Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, P, Pb, Sl, Sn, Sr, Tl, V, Zn	Same as Mercury except portion passing through was analyzed for metals. Sample was leached with HCl and HNO_3. The sample was heated for 3 hours.	Inductively Coupled Argon Plasma (ICAP)	320

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	PREPARATION	ANALYSIS	METHOD CODE[1]
Metals (Leachable) (continued)			
As	Same as other metals.	Hydride Generation ICAP	350
Ag	Same as other metals.	Flame Atomic Absorption Spectrophotometry	330
K	Same as other metals.	Flame Atomic Emission Spectrophotometry	340
Particle Size	Sample was freeze-dried.	Standard Sieving Operation	078

[1] Department of Environment, Department of Fisheries and Oceans, Laboratory Manual, Environmental Protection Service, Fisheries and Marine Service (1979).

APPENDIX I TABLE 3 BOTTOM FAUNA COLLECTION, PRESERVATION AND IDENTIFICATION METHODS

FIELD COLLECTION, SAMPLING PROCEDURES AND PRESERVATION	LABORATORY PROCEDURES	IDENTIFICATION AND ENUMERATION
Barbecue Chicken Basket: creek and river samples were taken using Barbecue Basket (17 x 25 cm) filled with local rocks. The rock size range was from 1 cm to 3 cm. No attempt was made to wash the rocks to remove the periphyton and biological film. The baskets stayed in the stream for 50 days. Three samples were taken at each station.	Bottom fauna was removed from other material and stored in a labelled vial containing 70% methanol.	Bottom fauna was sent to Dr. C. Low, Consulting Invertebrate Biologist, Nanaimo, B. C. for identification to genus, species if possible, and enumeration.

APPENDIX I TABLE 4 ATTACHED ALGAE COLLECTION, PRESERVATION AND IDENTIFICATION METHODS

FIELD COLLECTION, SAMPLING PROCEDURES AND PRESERVATION	LABORATORY PROCEDURES	IDENTIFICATION
The filamentous algae were collected by tearing the plant from the substrate near the attachment point. The algae was gently washed to remove the excess of an orange precipitate (iron sulfate). The sample was put in a Whirl Pak™ bag and kept cool. Inclusion of chironomids was avoided to the extent practical.	For the July samples, all the chironomids were separated and rinsed with tap water into a 450 um mesh seive before the sample was frozen. The samples were shipped to EPS Laboratory in West Vancouver. The September samples were frozen without sorting or rinsing and shipped to Vancouver for extractable metals analysis.	The identification was made from a subsample of the July 26 survey and kept in a solution of Lugols Iodine. The identification to the family was made by EPS Whitehorse staff.

APPENDIX I TABLE 5 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Physical				
Colour Pt. Counts	15	1		
Odour and taste	0	1		
Turbidity J.T.U.	5	1		
Chemical				
Alkalinity mg/L (Total)	Not considered a public health problem	4	>20	3
Aluminum (Al) mg/L	Not considered a public health problem	7	0.1	5
Ammonia (NH_3-N) mg/L	0.5 (Total)	4	0.02 (un-ionized)	3
Antimony (Sb) mg/L				
Arsenic (As) mg/L	0.05	1	0.05	2 (total)
Barium (Ba) mg/L	1.0	1	5.0	7
Boron (B) mg/L	1.0	1		
Cadmium (Cd) mg/L	0.005	1	0.0002	2 (total)
Calcium (Ca) mg/L	75-200	7		
Chloride (Cl) mg/L	250	1		
Chromium (Cr) mg/L	0.05	1	0.04	2 (total)
Cobalt (Co) mg/L				
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6
Copper (Cu) mg/L	1.0	1	0.002	2 (total)
Cyanide (CN) mg/L	0.2	1	0.005	3
Dissolved oxygen (% saturation)	Near 100%	4	$\geq$5.0 mg/L	3

APPENDIX I TABLE 5 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Fluoride (F) mg/L	1.5	1	1.5	7
Hardness (Total) as mg/L $CaCO_3$	80-100	1		
Iron (Fe) mg/L	0.3	1	1.0	3
Lead (Pb) mg/L	0.05	1	0.005 (soft H_2O*)	2 (total)
			0.01 (hard H_2O*)	2 (total)
Magnesium (Mg) mg/L	50	4		
Manganese (Mn) mg/L	0.05	1	1.0	7
Mercury (Hg) mg/L	0.002	1	0.0001-0.0002	2 (total)
Molybdenum (Mo) mg/L				
Nickel (Ni) mg/L	0.25	2	0.025 (soft H_2O*)	2 (total)
			0.25 (hard H_2O*)	2 (total)
Nitrate (NO_3-N) mg/L	10	1		
Nitrite (NO_2-N) mg/L	0.001	1		
pH units	6.5 - 8.5	1	6.5 - 9.0	3
Phosphorus (P) mg/L (Total)			0.020 to prevent algae	5
Potassium (K) mg/L				
Residue: Filterable mg/L (Total dissolved solids)	1000	4	70 - 400 with a maximum of 2000	6
Residue: Non-Filterable (mg/L)				
Selenium (Se) mg/L	0.01	1	0.01	2 (total)
Silica (Si) mg/L				
Silver (Ag) mg/L	0.05	1	0.0001	2 (total)
Sodium (Na) mg/L	20	1		
Strontium (Sr) mg/L	10	1		
Sulphate (SO_4) mg/L	500	1		

APPENDIX I TABLE 5 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Tin (Sn) mg/L	Not present in natural waters	7		
Titanium (Ti) mg/L				
Total Inorganic Carbon (TIC)				
Total Organic Carbon (TOC)	5.0	5		
Vanadium (V)				
Zinc (Zn) mg/L	5.0	1	0.030	5

* Soft water has a total hardness less than 95 mg/L as $CaCO_3$. Hard water has a total hardness of more than 95 mg/L as $CaCO_3$ (Reference 6).

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APPENDIX I TABLE 5 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)

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APPENDIX II

WATER QUALITY DATA

APPENDIX II TABLE 1 WATER QUALITY - PHYSICAL AND CHEMICAL PARAMETERS

STATION NUMBER	DATE	$\bar{x}$ S.D.	FLOW m^3/s	TEMP (°C)	D.O. (mg/l)	% D.O. SATURATION (%)	IN SITU pH	LAB pH	IN SITU CONDUCTIVITY (umhos/cm)	LAB CONDUCTIVITY (umhos/cm)	COLOUR (colour units)	TURBIDITY (FTU)
1	83/7/26	$\bar{x}$	0.997	9.0	10.2	88.3	7.3	7.6	70	108	10.0	0.20
		S.D.	-	-	-	-	-	0.0	-	0.6	0.0	0.0
	83/9/15	$\bar{x}$	-	7.0	10.6	87.5	-	7.7	90	141	7.5	0.10
		S.D.	-	-	-	-	-	0.0	-	0.0	2.04	0.0
2	83/7/26	$\bar{x}$	2.41	8.0	10.6	89.6	7.6	7.9	-	148	10.0	0.10
		S.D.	-	-	-	-	-	0.0	-	0.6	0.0	0.0
	83/9/15	$\bar{x}$	-	5.0	11.3	88.6	-	7.7	100	166	10.0	<0.10
		S.D.	-	-	-	-	-	0.0	-	1.4	0.0	0.0
3	83/7/26	$\bar{x}$	0.125	7.0	4.7	38.8	7.3	7.7	610	929	5.0	0.20
		S.D.	-	-	-	-	-	0.0	-	6.4	0.0	0.0
	83/9/15	$\bar{x}$	-	6.0	4.8	38.6	-	7.5	600	955	5.0	0.70
		S.D.	-	-	-	-	-	0.07	-	0.0	0.0	0.2
4	83/7/26	$\bar{x}$	3.10	10.0	9.7	86.1	7.7	7.9	180	252	5.0	0.10
		S.D.	-	-	-	-	-	0.0	-	0.0	0.0	0.0
	83/9/15	$\bar{x}$	-	4.5	10.9	85.5	-	7.9	170	289	5.0	0.10
		S.D.	-	-	-	-	-	0.0	-	0.0	0.0	0.0
5	83/7/26	$\bar{x}$	3.10	10.0	9.9	87.8	7.7	8.0	180	252	5.0	0.10
		S.D.	-	-	-	-	-	0.06	-	0.0	0.0	0.0
	83/9/15	$\bar{x}$	-	4.5	11.2	87.8	-	7.9	170	285	7.5	0.10
		S.D.	-	-	-	-	-	0.07	-	1.4	2.04	0.0

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 1 WATER QUALITY - PHYSICAL AND CHEMICAL PARAMETERS (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	FLOW m^3/s	TEMP (°C)	D.O. (mg/l)	% D.O. SATURATION (%)	IN SITU pH	LAB pH	IN SITU CONDUCTIVITY (umhos/cm)	LAB CONDUCTIVITY (umhos/cm)	COLOUR (colour units)	TURBIDITY (FTU)
6a	83/7/26	$\bar{x}$	4.50	10	10.3	91.4	7.9	7.9	170	241	5.0	<0.10
		S.D.	-	-	-	-	-	0.0	-	0.0	0.0	0.0
	83/9/15	$\bar{x}$	-	1.5	11.8	85.5	-	7.9	155	272	5.0	0.10
		S.D.	-	-	-	-	-	0.0	-	3.5	0.0	0.0
7a	83/7/26	$\bar{x}$	4.33	8.5	10.6	91.8	8.2	8.2	165	251	5.0	<0.10
		S.D.	-	-	-	-	-	0.0	-	0.0	0.0	0.0
	83/9/15	$\bar{x}$	-	2.5	12.0	89.3	-	8.0	140	253	7.5	0.10
		S.D.	-	-	-	-	-	0.0	-	0.0	2.04	0.0
8	83/7/26	$\bar{x}$	9.75	10	11.0	97.6	8.1	8.1	150	228	5.0	0.80
		S.D.	-	-	-	-	-	0.0	-	0.0	0.0	0.0
	83/9/15	$\bar{x}$	-	3	12.5	93.0	-	8.0	135	239	10.0	0.50
		S.D.	-	-	-	-	-	0.0	-	2.1	0.0	0.0
9	83/7/26	$\bar{x}$	-	12	8.6	79.9	8.0	8.1	200	245	5.0	4.40
		S.D.	-	-	-	-	-	0.0	-	3.5	0.0	0.0
	83/9/15	$\bar{x}$	-	5.5	8.0	62.3	-	7.8	165	263	10.0	1.95
		S.D.	-	-	-	-	-	0.0	-	6.36	0.0	1.34
10	83/7/26	$\bar{x}$	-	14	11.0	107	8.0	8.1	168	230	5.0	1.80
		S.D.	-	-	-	-	-	0.0	-	0.0	0.0	0.0
	83/9/15	$\bar{x}$	-	4	12.2	90.7	-	8.0	140	245	10.0	1.55
		S.D.	-	-	-	-	-	0.07	-	0.0	0.0	0.78

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 1 WATER QUALITY - PHYSICAL AND CHEMICAL PARAMETERS (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	N.F.R. (mg/l)	FR. (mg/l)	T. Alk. (mg/l $CaCO_3$)	T. Hard. (mg/l $CaCO_3$)	T.PO_4^-P (mg/l)	NO_2^-N (µ/l)	NO_3^-N (mg/l)	NH_3^-N (mg/l)	SO_4 (mg/l)	Cl (mg/l)
1	83/7/26	$\bar{x}$	<6.0	83.0	56.0	50.2	0.0060	<0.0050	0.020	0.0070	8.4	<0.50
		S.D.	0.6	1.0	0.0	0.4	0.001	0.0	0.0	0.001	0.5	0.06
	83/9/15	$\bar{x}$	<5.0	90.0	62.0	72.4	<0.0050	0.0090	0.010	0.0095	10.4	0.60
		S.D.	0.0	1.4	0.0	0.35	0.0	0.0	0.0	0.002	0.07	0.0
2	83/7/26	$\bar{x}$	<5.0	106	64.0	72.7	<0.0050	<0.0050	<0.010	0.0050	10.0	<0.50
		S.D.	0.0	2.9	0.0	0.6	0.0	0.0	0.0	0.0	0.2	0.0
	83/9/15	$\bar{x}$	<5.0	114	74.5	85.3	<0.0050	0.0090	0.010	0.0050	12.0	0.50
		S.D.	0.0	4.95	0.7	0.28	0.0	0.0	0.0	0.0	0.14	0.0
3	83/7/26	$\bar{x}$	<5.0	670	136	344	<0.0050	<0.0050	0.050	0.740	372	1.50
		S.D.	0.0	33.0	0.0	3.1	0.0	0.0	0.006	0.2	10.7	0.06
	83/9/15	$\bar{x}$	<5.0	714	162	354	0.0090	0.0130	0.023	0.449	468	1.80
		S.D.	0.0	2.12	0.7	2.8	0.004	0.0007	0.0035	0.008	10.6	0.0
4	83/7/26	$\bar{x}$	<5.0	117	77.0	103	<0.0050	<0.0050	0.030	0.0240	49.9	<0.50
		S.D.	0.0	9.5	0.0	1.0	0.0	0.0	0.0	0.002	0.8	0.0
	83/9/15	$\bar{x}$	<5.0	170	88.0	122	<0.0050	0.0100	0.023	0.0360	59.3	<0.50
		S.D.	0.0	23.3	0.0	0.7	0.0	0.0	0.0007	0.006	0.35	0.0
5	83/7/26	$\bar{x}$	<6.7	177	79.0	106	<0.0050	<0.0050	0.030	0.0180	47.8	<0.50
		S.D.	2.9	10.8	0.0	1.5	0.0	0.0	0.0	0.0006	0.9	0.0
	83/9/15	$\bar{x}$	186	158	89.5	123	<0.0050	0.0100	0.031	0.0310	55.3	<0.50
		S.D.	257	2.0	0.7	1.4	0.0	0.0	0.0007	0.002	0.35	0.0

$\bar{x}$ = arithmetic mean
S.D. = standard deviation

APPENDIX II TABLE 1 WATER QUALITY - PHYSICAL AND CHEMICAL PARAMETERS (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	N.F.R. (mg/l)	ER. (mg/l)	T. Alk. (mg/l $CaCO_3$)	T. Hard. (mg/l $CaCO_3$)	PO_4^-P (mg/l)	NO_2^-N (mg/l)	NO_3^-N (mg/l)	NH_3^-N (mg/l)	SO_4 (mg/l)	(mg/l)
6a	83/7/26	$\bar{x}$	<7.0	162	76.0	104	<0.0050	<0.0050	0.040	0.0080	42.0	<0.50
		S.D.	3.0	1.2	0.0	1.2	0.0	0.0	0.0	0.002	0.1	0.0
	83/9/15	$\bar{x}$	430	202	88.0	119	<0.0050	0.0110	0.045	0.0190	50.0	<0.50
		S.D.	66.5	55.8	0.0	0.7	0.0	0.0	0.002	0.0007	0.0	0.0
7a	83/7/26	$\bar{x}$	<5.0	165	113	125	<0.0050	<0.0050	0.040	<0.0050	18.0	<0.50
		S.D.	0.0	2.0	1.2	1.7	0.0	0.0	0.0	0.0006	0.2	0.0
	83/9/15	$\bar{x}$	110	176	112	132	0.0080	0.0110	0.065	0.0070	20.3	<0.50
		S.D.	32.5	4.2	2.1	1.4	0.002	0.0	0.004	0.0007	1.4	0.0
8	83/7/26	$\bar{x}$	<3.7	152	86.0	104	0.0060	<0.0050	0.020	0.0080	27.6	<0.50
		S.D.	2.1	5.2	0.0	1.0	0.002	0.0	0.0	0.001	0.3	0.06
	83/9/15	$\bar{x}$	54.0	168	93.0	116	0.0060	0.0110	0.038	0.0080	31.7	<0.50
		S.D.	39.6	0.7	0.0	0.7	0.0	0.0	0.0	0.0007	0.2	0.0
9	83/7/26	$\bar{x}$	<7.7	168	87.0	120	0.0160	<0.0050	<0.010	0.0070	36.2	<0.50
		S.D.	2.1	1.0	1.2	1.2	0.002	0.0	0.0	0.002	0.2	0.0
	83/9/15	$\bar{x}$	30.0	172	99.5	131	0.0090	0.0110	0.010	0.0090	37.8	<0.50
		S.D.	2.8	0.7	3.5	1.4	0.004	0.0	0.0	0.003	0.7	0.0
10	83/7/26	$\bar{x}$	<5.7	157	86.0	117	0.0100	<0.0050	0.020	0.0110	30.4	<0.50
		S.D.	1.2	1.7	1.5	0.6	0.001	0.0	0.0	0.002	0.06	0.0
	83/9/15	$\bar{x}$	<6.0	163	93.0	118	0.0070	0.0110	0.022	0.0090	32.9	<0.50
		S.D.	0.7	5.7	0.0	1.4	0.001	0.0	0.0	0.003	0.07	0.0

$\bar{x}$ = arithmentic mean
S.D.= standard deviation

APPENDIX II TABLE 2 WATER QUALITY-EXTRACTABLE METALS (mg/l)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Ag mg/l	Al mg/l	As mg/l	B mg/l	Ba mg/l	Be mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l
1	83/7/26	$\bar{x}$	<0.00050	<0.050	<0.00050	0.0180	0.026	<0.0010	15.1	0.00060	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.0	0.0	0.0	0.0006	0.0	0.15	0.0002	0.0	0.0	0.0
	83/9/15	$\bar{x}$	<0.00050	0.060	<0.00050	0.0120	0.050	<0.0010	22.2	<0.00050	<0.0050	<0.0050	0.0170
		S.D.	0.0	0.01	0.0	0.0	0.0007	0.0	0.07	0.0	0.0	0.0	0.001
2	83/7/26	$\bar{x}$	<0.00050	0.060	0.00050	0.0180	0.039	<0.0010	21.1	<0.00050	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.0006	0.0001	0.0	0.0	0.0	0.17	0.0	0.0	0.0	0.0006
	83/9/15	$\bar{x}$	<0.00050	<0.050	<0.00050	0.0120	0.060	<0.0010	25.1	<0.00050	<0.0050	<0.0050	0.0300
		S.D.	0.0	0.0	0.0	0.0	0.02	0.0	0.14	0.0	0.0	0.0	0.005
3	83/7/26	$\bar{x}$	<0.00050	<0.050	0.00120	<0.0010	0.075	<0.0010	106	<0.00050	<0.0050	<0.0050	<0.0010
		S.D.	0.0	0.0	0.0004	0.0	0.0	0.0	0.58	0.0	0.0	0.0	0.0
	83/9/15	$\bar{x}$	<0.00050	0.060	0.00200	0.0050	0.103	<0.0010	111	<0.00500	<0.0060	<0.0050	0.0270
		S.D.	0.0	0.01	0.0	0.002	0.03	0.0	1.4	0.0	0.0007	0.0	0.0
4	83/7/26	$\bar{x}$	<0.00050	<0.050	0.00070	0.0290	0.045	<0.0010	30.6	<0.00050	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.0	0.0	0.003	0.0006	0.0	0.31	0.0	0.0	0.0	0.0
	83/9/15	$\bar{x}$	<0.00050	<0.050	<0.00050	0.0120	0.052	<0.0010	37.0	<0.00050	<0.0060	<0.0050	0.0150
		S.D.	0.0	0.0	0.0	0.0	0.006	0.0	0.35	0.0	0.0007	0.0	0.004
5	83/7/26	$\bar{x}$	<0.00050	<0.050	<0.00050	0.0140	0.046	<0.0010	31.6	<0.00050	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.0	0.0	0.023	0.001	0.0	0.5	0.0	0.0	0.0	0.0006
	83/9/15	$\bar{x}$	<0.00050	<0.050	<0.00050	0.0120	0.076	<0.0010	37.2	<0.00050	<0.0050	<0.0050	0.0120
		S.D.	0.0	0.0	0.0	0.0	0.040	0.0	0.42	0.0	0.0	0.0	0.002

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 2 WATER QUALITY-EXTRACTABLE METALS (mg/l) (continued

STATION NUMBER	DATE	$\bar{x}$ S.D.	Ag mg/l	Al mg/l	As mg/l	B mg/l	Ba mg/l	Be mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l
6a	83/7/26	$\bar{x}$	<0.00050	<.060	<0.00050	0.0040	0.063	<0.0010	31.0	<0.00050	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.02	0.0	0.003	0.002	0.0	0.3	0.0	0.0	0.0	0.0006
	83/9/15	$\bar{x}$	<0.00050	<.050	<0.00050	0.0190	0.068	<0.0010	35.9	<0.00050	<0.0050	<0.0050	0.0110
		S.D.	0.0	0.0	0.0	0.0	0.008	0.0	0.28	0.0	0.0	0.0	0.001
7a	83/7/26	$\bar{x}$	<0.00050	<.050	<0.00050	<0.0030	0.060	<0.0010	34.9	<0.00050	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.0	0.0	0.002	0.002	0.0	0.4	0.0	0.0	0.0	0.002
	83/9/15	$\bar{x}$	<0.00050	0.120	<0.00050	0.0190	0.070	<0.0010	37.4	<0.00050	<0.0050	<0.0050	0.0100
		S.D.	0.0	0.007	0.0	0.0007	0.006	0.0	0.42	0.0	0.0	0.0	0.004
8	83/7/26	$\bar{x}$	<0.00050	0.090	0.00060	0.0150	0.058	<0.0010	30.4	<0.00050	<0.0050	<0.0050	0.0030
		S.D.	0.0	0.02	0.0001	0.005	0.0006	0.0	0.32	0.0	0.0	0.0	0.0006
	83/9/15	$\bar{x}$	<0.00050	0.090	<0.00050	0.0190	0.067	<0.0010	34.4	<0.00050	<0.0050	<0.0050	0.0110
		S.D.	0.0	0.01	0.0	0.0007	0.004	0.0	0.35	0.0	0.0	0.0	0.003
9	83/7/26	$\bar{x}$	<0.00050	0.080	0.00070	<0.0040	0.077	<0.0010	32.3	<0.00050	<0.0050	<0.0050	0.0030
		S.D.	0.0	0.005	0.0001	0.003	0.0006	0.0	0.35	0.0	0.0	0.0	0.001
	83/9/15	$\bar{x}$	<0.00050	0.070	<0.0005	0.0180	0.108	<0.0010	36.05	<0.00050	<0.0050	<0.0050	0.0120
		S.D.	0.0	0.007	0.0	0.0	0.0014	0.0	0.35	0.0	0.0	0.0	0.0007
10	83/7/26	$\bar{x}$	<0.00050	0.080	0.00070	<0.0100	0.062	<0.0010	30.6	<0.00050	<0.0050	<0.0050	0.0020
		S.D.	0.0	0.01	0.0001	0.02	0.0006	0.0	0.25	0.0	0.0	0.0	0.0
	83/9/15	$\bar{x}$	<0.00050	0.070	<0.00050	0.0120	0.060	<0.0010	34.3	<0.00050	<0.0050	<0.0050	0.0110
		S.D.	0.0	0.007	0.0	0.0085	0.0014	0.0	0.35	0.0	0.0	0.0	0.004

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 2 WATER QUALITY-EXTRACTABLE METALS (mg/l) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Fe mg/l	K mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	Pb mg/l	Sb mg/l	Se mg/l	Si mg/l
1	83/7/26	$\bar{x}$	0.170	0.730	2.8	0.014	<0.0050	1.0	0.030	<0.0010	<0.050	<0.050	2.9
		S.D.	0.0021	0.015	0.06	0.002	0.0	0.06	0.006	0.0	0.0	0.0	0.0
	83/9/15	$\bar{x}$	0.160	0.698	3.9	0.019	<0.0050	1.6	<0.020	0.0020	<0.050	<0.050	4.0
		S.D.	0.010	0.0	0.0	0.003	0.0	0.0	0.0	0.0007	0.0	0.0	0.07
2	83/7/26	$\bar{x}$	0.160	0.610	4.6	0.024	<0.0050	1.3	<0.020	<0.0020	<0.050	<0.050	3.9
		S.D.	0.005	0.014	0.06	0.0006	0.0	0.06	0.006	0.0006	0.0	0.0	0.06
	83/9/15	$\bar{x}$	0.127	0.626	5.2	0.038	<0.0050	1.8	0.030	0.0040	<0.050	<0.050	4.8
		S.D.	0.0007	0.0	0.0	0.0007	0.0	0.0	0.007	0.001	0.0	0.0	0.0
3	83/7/26	$\bar{x}$	0.057	4.01	17.7	2.60	<0.0050	74.7	<0.020	<0.0010	<0.050	<0.050	4.6
		S.D.	0.005	0.09	0.17	0.06	0.0	1.2	0.0	0.0	0.0	0.0	0.06
	83/9/15	$\bar{x}$	0.456	4.27	17.0	2.90	<0.0050	76.6	<0.020	<0.0010	<0.050	<0.050	5.0
		S.D.	0.06	0.0	0.07	0.02	0.0	0.7	0.0	0.0	0.0	0.0	0.0
4	83/7/26	$\bar{x}$	0.150	0.990	6.2	0.260	<0.0050	8.2	<0.020	<0.0010	<0.050	<0.050	4.1
		S.D.	0.0021	0.016	0.1	0.006	0.0	0.06	0.006	0.0	0.0	0.0	0.06
	83/9/15	$\bar{x}$	0.149	1.08	7.0	0.444	<0.0050	11.6	<0.020	0.0020	<0.050	<0.050	4.9
		S.D.	0.0007	0.0	0.07	0.002	0.0	0.07	0.0	0.0007	0.0	0.0	0.07
5	83/7/26	$\bar{x}$	0.130	1.03	6.3	0.220	<0.0050	8.0	0.030	<0.0010	<0.050	<0.050	4.2
		S.D.	0.006	0.02	0.1	0.004	0.0	0.15	0.0	0.0006	0.0	0.0	0.1
	83/9/15	$\bar{x}$	0.136	1.08	7.0	0.384	<0.0050	10.9	<0.020	0.0020	<0.050	<0.050	4.9
		S.D.	0.001	0.0	0.07	0.002	0.0	0.14	0.0	0.0007	0.0	0.0	0.0

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 2 WATER QUALITY-EXTRACTABLE METALS (mg/l) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Fe mg/l	K mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Na mg/l	Ni mg/l	Pb mg/l	Sb mg/l	Se mg/l	Si mg/l
6a	83/7/26	$\bar{x}$	0.120	1.03	6.3	0.135	<0.0050	7.1	<0.020	<0.0010	<0.050	<0.050	4.2
		S.D.	0.02	0.02	0.06	0.002	0.0	0.06	0.0	0.0	0.0	0.0	0.06
	83/9/15	$\bar{x}$	0.137	1.08	6.8	0.270	<0.0050	9.4	<0.020	0.0020	<0.050	<0.050	4.9
		S.D.	0.006	0.0	0.07	0.002	0.0	0.07	0.0	0.001	0.0	0.0	0.07
7a	83/7/26	$\bar{x}$	0.106	0.930	9.0	0.010	<0.0050	1.5	0.040	<0.0010	<0.050	<0.050	4.0
		S.D.	0.016	0.0	0.12	0.0006	0.0	0.06	0.02	0.0	0.0	0.0	0.0
	83/9/15	$\bar{x}$	0.277	0.997	9.0	0.039	<0.0050	1.8	<0.020	0.0020	<0.050	<0.050	4.7
		S.D.	0.006	0.0	0.14	0.004	0.0	0.0	0.0	0.0	0.0	0.0	0.07
8	83/7/26	$\bar{x}$	0.182	1.12	6.6	0.023	<0.0050	3.9	0.030	<0.0010	<0.050	<0.050	4.2
		S.D.	0.015	0.005	0.06	0.002	0.0	0.06	0.006	0.0	0.0	0.0	0.0
	83/9/15	$\bar{x}$	0.190	1.14	6.9	0.072	<0.0050	4.9	<0.020	0.0010	<0.050	<0.050	4.8
		S.D.	0.013	0.0	0.0	0.0007	0.0	0.07	0.0	0.0	0.0	0.0	0.0
9	83/7/26	$\bar{x}$	0.205	0.770	9.4	0.013	<0.0050	2.0	0.050	<0.0010	<0.050	<0.050	2.9
		S.D.	0.012	0.03	0.12	0.0006	0.0	0.06	0.03	0.0	0.0	0.0	0.06
	83/9/15	$\bar{x}$	0.160	0.773	9.8	0.012	<0.0050	2.6	<0.020	0.0010	<0.050	<0.050	3.4
		S.D.	0.009	0.0	0.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	83/7/26	$\bar{x}$	0.138	1.01	7.3	0.020	<0.0050	3.2	0.050	<0.0010	<0.050	<0.050	3.8
		S.D.	0.03	0.0	0.1	0.0006	0.0	0.06	0.02	0.0	0.0	0.0	0.06
	83/9/15	$\bar{x}$	0.156	1.03	7.7	0.050	<0.0050	4.1	<0.020	0.0010	<0.050	<0.050	4.4
		S.D.	0.0007	0.0	0.07	0.0007	0.0	0.07	0.0	0.0	0.0	0.0	0.0

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 2 WATER QUALITY-EXTRACTABLE METALS (mg/l) (continued

STATION NUMBER	DATE	$\bar{x}$ S.D.	Sn mg/l	Sr mg/l	Tl mg/l	V mg/l	Zn mg/l
1	83/7/26	$\bar{x}$	<0.010	0.078	0.0050	<0.010	0.0300
		S.D.	0.0	0.001	0.0006	0.0	0.0006
	83/9/15	$\bar{x}$	<0.010	0.105	0.0040	<0.010	0.133
		S.D.	0.0	0.0007	0.0007	0.0	0.015
2	83/7/26	$\bar{x}$	<0.010	0.094	0.0040	<0.010	0.0460
		S.D.	0.0	0.002	0.0	0.0	0.004
	83/9/15	$\bar{x}$	<0.010	0.106	0.0020	<0.010	0.293
		S.D.	0.0	0.0	0.0	0.0	0.01
3	83/7/26	$\bar{x}$	<0.010	0.352	<0.0020	<0.010	<0.0020
		S.D.	0.0	0.004	0.0	0.0	0.0
	83/9/15	$\bar{x}$	<0.010	0.335	0.0030	<0.010	0.140
		S.D.	0.0	0.003	0.0	0.0	0.104
4	83/7/26	$\bar{x}$	<0.010	0.122	0.0040	<0.010	0.0580
		S.D.	0.0	0.001	0.006	0.0	0.002
	83/9/15	$\bar{x}$	<0.010	0.133	0.0020	<0.010	0.105
		S.D.	0.0	0.001	0.0	0.0	0.012
5	83/7/26	$\bar{x}$	<0.010	0.12	<0.0020	<0.010	0.0460
		S.D.	0.0	0.003	0.0	0.0	0.005
	83/9/15	$\bar{x}$	<0.010	0.133	<0.0020	<0.010	0.117
		S.D.	0.0	0.002	0.7	0.0	0.06

$\bar{x}$ - Arithmetic mean
S.D. - Standard deviation

APPENDIX II TABLE 2 WATER QUALITY-EXTRACTABLE METALS (mg/l) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Sn mg/l	Sr mg/l	Tl mg/l	V mg/l	Zn mg/l
6a	83/7/26	$\bar{x}$	<0.01	0.120	<0.0020	<0.01	0.050
		S.D.	0.0	0.001	0.0006	0.0	0.010
	83/9/15	$\bar{x}$	<0.01	0.127	<0.0020	<0.01	0.072
		S.D.	0.0	0.0007	0.0	0.0	0.016
7a	83/7/26	$\bar{x}$	<0.01	0.106	<0.0030	<0.01	0.034
		S.D.	0.0	0.002	0.0006	0.0	0.020
	83/9/15	$\bar{x}$	<0.01	0.104	0.0060	<0.01	0.031
		S.D.	0.0	0.0007	0.0	0.0	0.004
8	83/7/26	$\bar{x}$	<0.01	0.106	0.0070	<0.01	0.036
		S.D.	0.0	0.002	0.0006	0.0	0.004
	83/9/15	$\bar{x}$	<0.01	0.109	0.0050	<0.01	0.049
		S.D.	0.0	0.001	0.0007	0.0	0.005
9	83/7/26	$\bar{x}$	<0.01	0.141	0.0050	<0.01	0.043
		S.D.	0.0	0.002	0.0020	0.0	0.020
	83/9/15	$\bar{x}$	<0.01	0.142	<0.0020	<0.01	0.040
		S.D.	0.0	0.001	0.0	0.0	0.008
10	83/7/26	$\bar{x}$	<0.01	0.115	0.0060	<0.01	0.040
		S.D.	0.0	0.001	0.0006	0.0	0.020
	83/9/15	$\bar{x}$	<0.01	0.117	0.0020	<0.01	0.038
		S.D.	0.0	0.002	0.0	0.0	0.014

$\bar{x}$ Arithmetic mean
S.D. Standard deviation

APPENDIX III

SEDIMENT DATA

APPENDIX III TABLE 1 SEDIMENT PARTICLE SIZE - MEAN AND STANDARD DEVIATION

JULY 25, 1983 AND SEPTEMBER 15, 1983

STATION NUMBER		PERCENT COMPOSITION					
		<.063 mm	.063-.15 mm	.15-.25 mm	.25-.5 mm	.5-1.0 mm	>1.0 mm
	$\bar{x}$ S.D.	SILT & CLAY	V. FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL
1	$\bar{x}$	0.6	3.6	6.1	8.7	9.4	71.4
	S.D.	0.8	2.1	4.1	3.6	3.9	14.4
2	$\bar{x}$	1.0	3.5	2.1	5.7	16.7	70.7
	S.D.	1.3	1.4	1.3	3.7	4.0	11.0
3	$\bar{x}$	2.3	6.3	3.4	6.2	7.2	74.2
	S.D.	1.9	0.7	0.1	0.7	0.5	0.8
4	$\bar{x}$	3.4	8.8	7.4	7.9	4.8	67.9
	S.D.	3.6	8.6	5.7	0.8	0.6	18.2
5	$\bar{x}$	0.6	1.8	2.2	8.6	16.8	70.3
	S.D.	0.1	0.9	0.8	0.4	0.5	2.7
6a	$\bar{x}$	1.3	3.3	2.9	9.2	27.2	56.3
	S.D.	0.4	0.07	0.5	0.4	0.4	3.5
7a	$\bar{x}$	3.1	26.0	38.1	29.1	3.3	0.7
	S.D.	1.6	2.6	1.3	4.3	1.2	0.1
8	$\bar{x}$	0.1	0.3	1.5	13.8	24.8	59.8
	S.D.	0.0	0.07	0.2	0.6	4.2	3.9
9	$\bar{x}$	1.5	2.0	3.6	7.8	4.7	80.6
	S.D.	0.1	0.4	0.2	0.8	0.6	1.9
10	$\bar{x}$	23.4	59.6	9.9	3.6	2.0	1.6
	S.D.	10.3	10.7	2.3	1.1	0.8	0.07

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX III TABLE 2 SEDIMENT - LEACHABLE METALS (mg/kg)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Ag mg/kg	Al mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Ca mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg
	83/7/26	$\bar{x}$	---	16000	14.7	233	0.53	6390	0.77	14.2	34.6	26.1	25633.3
1		S.D.	---	2220	3.2	11.0	0.12	688	0.15	2.0	5.6	1.0	3927.3
	83/9/15	$\bar{x}$	0.38	15800	16.0	360	0.55	6770	0.85	12.9	36.7	25.0	25450.0
		S.D.	0.01	212	0.0	64.3	0.07	480	0.20	2.7	1.7	4.0	919.2
	83/7/26	$\bar{x}$	---	15200	21.3	482	0.50	9730	0.83	20.3	68.5	54.2	25366.7
2		S.D.	---	1258	7.6	85.8	0.0	1030	0.06	4.5	13.0	3.2	4839.8
	83/9/15	$\bar{x}$	0.51	16400	22.5	506	0.65	9010	0.70	17.3	59.7	45.4	26600.0
		S.D.	0.03	778	0.7	46.0	0.07	42.4	0.0	0.1	1.13	1.0	282.8
	83/7/26	$\bar{x}$	---	17000	33.3	1940	0.37	8770	1.20	17.0	43.3	58.9	35166.7
3		S.D.	---	1861	12.7	474	0.06	1400	0.36	2.3	4.6	13.3	3262.4
	83/9/15	$\bar{x}$	0.29	16800	20.5	1490	0.50	22600	3.20	14.5	45.5	47.6	29300.0
		S.D.	0.003	1131	0.7	148	0.0	6860	0.64	0.4	0.42	3.5	848.5
	83/7/26	$\bar{x}$	---	14900	109	3040	0.40	7450	1.57	33.6	49.9	130	66400.0
4		S.D.	---	723	14.0	651	0.0	284	0.12	1.4	2.06	13.5	6657.3
	83/9/15	$\bar{x}$	1.16	16000	62.0	3600	0.55	9440	0.85	28.7	52.9	102	53050.0
		S.D.	0.24	1131	18.4	28.3	0.07	1360	0.07	5.2	1.9	0.7	8697.4
	83/7/26	$\bar{x}$	---	14100	118	2970	0.37	7030	1.50	34.9	43.2	119	68066.7
5		S.D.	---	404	14.6	368	0.06	128	0.15	2.4	1.7	4.0	6178.5
	83/9/15	$\bar{x}$	1.42	14300	89.0	2860	0.55	7560	0.75	34.8	42.7	114	66050.0
		S.D.	0.16	2334	2.8	608	0.07	778	0.07	1.7	7.64	2.1	212.1

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX III TABLE 2 SEDIMENT - LEACHABLE METALS (mg/kg) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Ag mg/kg	Al mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Ca mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg
6a	83/7/26	$\bar{x}$	---	14500	71.7	5990	0.60	6730	1.73	22.9	39.7	224	39500
		S.D.	---	2310	13.9	1660	0.40	620	0.25	5.3	5.9	98.8	30200
	83/9/15	$\bar{x}$	1.12	15400	30.5	3660	0.65	5800	0.55	18.4	41.4	120	35400
		S.D.	0.2	212	6.4	622	0.07	721	0.20	1.2	0.2	3.5	424
7a	83/7/26	$\bar{x}$	---	14100	62.7	3620	0.40	6180	1.50	21.7	38.6	119	50100
		S.D.	---	802	20.0	1470	0.00	232	0.06	2.6	1.5	2.6	7700
	83/9/15	$\bar{x}$	1.32	12600	79.0	4140	0.40	6230	0.60	25.5	34.2	116	54700
		S.D.	0.09	778	15.6	1560	0.00	42.4	0.00	2.4	1.6	12.0	6080
8	83/7/26	$\bar{x}$	---	12800	17.0	1240	0.20	16500	1.10	12.9	52.5	28.8	23000
		S.D.	---	1300	7.8	222	0.00	4590	0.40	2.3	2.8	2.2	1740
	83/9/15	$\bar{x}$	0.83	15000	12.3	1550	0.35	15000	1.90	13.8	85.9	30.7	27800
		S.D.	0.96	636	0.4	424	0.07	141	1.90	1.9	4.6	1.1	707
9	83/7/26	$\bar{x}$	---	10200	12.3	3830	0.27	25500	1.00	6.4	44.0	23.4	21700
		S.D.	---	116	0.6	826	0.06	656	0.20	4.0	5.5	1.1	874
	83/9/15	$\bar{x}$	1.18	12600	11.5	2950	0.04	22200	1.00	8.0	44.1	26.2	22900
		S.D.	0.04	0	2.1	156	0.00	70.7	0.14	2.4	1.5	1.3	141
10	83/7/26	$\bar{x}$	---	13400	11.0	864	0.30	16300	1.30	10.9	38.2	32.3	21300
		S.D.	---	1010	1.7	79.7	0.00	874	0.00	2.7	2.6	1.0	907
	83/9/15	$\bar{x}$	0.27	15200	13.5	768	0.50	15600	0.90	12.5	40.0	33.8	22600
		S.D.	0.02	636	0.7	33.2	0.00	354	0.14	3.7	1.0	1.5	636

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX III TABLE 2 SEDIMENT - LEACHABLE METALS (mg/kg) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Hg mg/kg	K mg/kg	Mg mg/kg	Mn mg/kg	Mo mg/kg	Na mg/kg	Ni mg/kg	P mg/kg	Pb mg/kg	Si mg/kg	Sn mg/kg
1	83/7/26	$\bar{x}$	0.20	---	6420	1340	2.90	483	27.7	932	124	4260	4.3
		S.D.	0.04	---	982	699	0.56	28.7	4.2	68.2	22.1	873	2.5
	83/9/15	$\bar{x}$	0.25	1800	5410	904	4.80	520	26.5	1150	198	2790	<2.0
		S.D.	0.008	[illegible]	233	248	0.14	14.1	0.7	184	36.0	127	0.0
2	83/7/26	$\bar{x}$	0.45	---	8670	544	3.77	360	69.0	985	368	4220	2.7
		S.D.	0.05	---	1370	148	0.76	10.0	12.0	40.4	37.0	163	0.6
	83/9/15	$\bar{x}$	0.70	2410	7120	509	6.60	425	57.5	1000	338	2390	3.5
		S.D.	0.42	240	177	21.2	0.14	35.4	0.7	53.0	24.7	700	0.7
3	83/7/26	$\bar{x}$	0.29	---	8670	872	5.90	647	41.0	997	93.3	4210	5.3
		S.D.	0.12	---	1960	855	0.70	206	4.4	50.8	34.5	164	3.1
	83/9/15	$\bar{x}$	0.21	2205	7140	844	7.20	565	47.0	1010	87.5	2190	<2.0
		S.D.	0.016	148	226	161	0.30	35.4	0.0	36.0	2.1	863	0.0
4	83/7/26	$\bar{x}$	1.24	---	7000	866	6.07	413	37.7	983	775	4840	<2.0
		S.D.	0.20	---	367	270	1.76	11.5	6.0	30.6	50.2	37.9	0.0
	83/9/15	$\bar{x}$	0.86	2300	7120	1240	10.8	470	40.0	1040	554	2280	<2.0
		S.D.	0.26	113	601	428	0.57	28.3	2.8	60.1	97.6	148	0.0
5	83/7/26	$\bar{x}$	1.15	---	6180	1070	7.40	407	33.0	1010	681	4590	<2.0
		S.D.	0.11	---	105	186	1.90	11.5	2.6	15.3	53.3	238	0.0
	83/9/15	$\bar{x}$	0.97	1925	5860	2030	11.2	425	31.5	1040	682	2690	<2.0
		S.D.	0.02	375	834	764	0.07	77.8	7.8	21.2	31.8	608	0.0

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX III TABLE 2 SEDIMENT - LEACHABLE METALS (mg/kg) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Hg mg/kg	K mg/kg	Mg mg/kg	Mn mg/kg	Mo mg/kg	Na mg/kg	Ni mg/kg	P mg/kg	Pb mg/kg	Si mg/kg	Sn mg/kg
6a	83/7/26	$\bar{x}$	1.26	---	5930	2780	8.17	547	32.0	1020	585	8270	6.0
		S.D.	0.1	---	972	945	2.15	230	8.2	20.8	107	6010	4.0
	83/9/15	$\bar{x}$	0.80	2260	5730	666	7.40	390	33.0	1100	899	2950	<2.0
		S.D.	0.04	262	311	23.3	1.4	0.0	0.0	120	157	240	0.0
7a	83/7/26	$\bar{x}$	1.02	---	6150	1040	6.60	397	27.3	924	510	4520	<2.0
		S.D.	0.11	---	428	50.5	1.3	11.5	4.0	65.9	75.8	211	0.0
	83/9/15	$\bar{x}$	0.88	1750	5060	762	10.8	400	22.0	1100	504	2860	<2.0
		S.D.	0.11	127	276	67.9	0.6	14.1	1.4	77.8	41.0	56.6	0.0
8	83/7/26	$\bar{x}$	0.13	---	8460	497	3.00	380	37.7	1340	46.0	4620	5.0
		S.D.	0.02	---	1320	59.2	1.2	17.3	4.2	83.9	3.6	315	4.4
	83/9/15	$\bar{x}$	0.12	2020	9100	992	6.00	470	49.0	1330	54.0	3120	11.0
		S.D.	--	120	693	96.2	0.99	28.3	1.4	99.0	5.7	148	2.8
9	83/7/26	$\bar{x}$	0.11	---	14500	447	3.80	220	36.0	2050	12.0	4980	3.0
		S.D.	0.02	---	755	9.2	0.46	20.0	3.0	98.7	3.5	296	1.7
	83/9/15	$\bar{x}$	0.15	2760	12800	514	4.90	210	38.0	1670	10.5	3380	<2.0
		S.D.	0.014	70.7	70.7	23.3	0.07	14.1	2.8	28.3	2.1	106	0.0
10	83/7/26	$\bar{x}$	0.18	---	9490	575	3.10	340	40.0	1150	42.3	5120	2.3
		S.D.	0.02	---	206	51.4	0.7	10.0	1.0	76.4	2.1	512	0.6
	83/9/15	$\bar{x}$	0.15	2650	9250	745	4.30	340	40.5	1100	44.5	3540	<2.0
		S.D.	0.004	184	283	36.8	0.4	28.3	0.7	14.1	0.7	42.4	0.0

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX III TABLE 2 SEDIMENT - LEACHABLE METALS (mg/kg) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Sr mg/kg	Tl mg/kg	V mg/kg	Zn mg/kg
1	83/7/26	$\bar{x}$	64.8	579	34.7	215
		S.D.	4.7	79.4	4.9	49.3
	83/9/15	$\bar{x}$	62.7	772	42.5	304
		S.D.	0.3	121	4.9	46.0
2	83/7/26	$\bar{x}$	56.7	543	45.3	300
		S.D.	4.6	20.6	2.5	29.0
	83/9/15	$\bar{x}$	56.9	692	48.0	298
		S.D.	1.3	36.1	1.4	3.5
3	83/7/26	$\bar{x}$	108	735	45.3	282
		S.D.	76.4	53.5	6.8	73.3
	83/9/15	$\bar{x}$	83.4	692	48.5	327
		S.D.	6.6	75.7	2.1	11.3
4	83/7/26	$\bar{x}$	58.9	679	44.7	967
		S.D.	2.1	21.7	1.2	92.3
	83/9/15	$\bar{x}$	68.4	745	46.0	868
		S.D.	3.9	0.0	2.8	19.8
5	83/7/26	$\bar{x}$	57.6	666	41.7	1000
		S.D.	1.6	43.4	1.5	78.2
	83/9/15	$\bar{x}$	58.0	746	43.5	992
		S.D.	7.8	98.3	4.9	82.7

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX III TABLE 2 SEDIMENT - LEACHABLE METALS (mg/kg) (continued)

STATION NUMBER	DATE	$\bar{x}$ S.D.	Sr mg/kg	Tl mg/kg	V mg/kg	Zn mg/kg
6a	83/7/26	$\bar{x}$	71.5	758	45.7	1020
		S.D.	13.6	17.1	5.1	20.8
	83/9/15	$\bar{x}$	55.7	748	45.0	750
		S.D.	3.0	24.7	1.4	144.2
7a	83/7/26	$\bar{x}$	60.5	717	44.3	977
		S.D.	9.1	112.9	0.6	75.1
	83/9/15	$\bar{x}$	57.1	746	42.5	778
		S.D.	7.2	17.7	0.7	38.2
8	83/7/26	$\bar{x}$	68.5	859	56.3	133
		S.D.	9.3	22.5	3.2	12.9
	83/9/15	$\bar{x}$	72.0	1180	66.5	156
		S.D.	0.7	49.5	2.1	3.5
9	83/7/26	$\bar{x}$	100	457	64.7	142
		S.D.	5.3	54.7	3.5	5.1
	83/9/15	$\bar{x}$	87.6	470	78.0	169
		S.D.	0.07	38.9	1.4	2.8
10	83/7/26	$\bar{x}$	69.1	519	58.7	180
		S.D.	2.2	51.3	4.0	11.6
	83/9/15	$\bar{x}$	66.4	602	63.5	202
		S.D.	1.6	26.2	2.1	10.0

$\bar{x}$ - arithmetic mean
S.D. - standard deviation

APPENDIX IV

BOTTOM FAUNA DATA

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BOTTOM FAUNA AT CYPRUS ANVIL, SEPTEMBER, 1983

	Phylum:	Coelenterata
	Order:	Hydroida
	Family:	Hydridae
1.		*Hydra* sp.
2.	Phylum:	Nematoda
	Phylum:	Annelida
	Class:	Oligochaeta
	Order:	Haplotaxida
3.	Family:	Enchytraeidae
	Family:	Naididae
4.		*Paranais* sp.
5.		*Nais* sp.
6.	Family:	Tubificidae
	Phylum:	Arthropoda
	Class:	Crustacea
	Order:	Cladocera
	Family:	Daphnidae
7.		*Daphnia rosea*
	Order:	Copepoda
	Family:	Cyclopidae
8.		*Cyclops* sp.
	Family:	Diaptomidae
9.		*Diaptomus* sp.
10.	Order:	Ostracoda
	Class:	Arachnoidea
11.	Subclass:	Arachnida
12.	Order:	Acari
	Class:	Insecta
	Order:	Collembola
13.	Family:	Isotomidae
	Order:	Plecoptera
	Family:	Capniidae
14.		*Capnia* sp.
	Family:	Chloroperlidae

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BOTTOM FAUNA AT CYPRUS ANVIL, SEPTEMBER, 1983 (continued)

15.		*Kathroperla* sp.
16.		*Alloperla* sp.
	Family:	Nemouridae
17.		(*Amphinemura* sp. or *Amphinemoura* sp.)
18.		*Prostoia* sp.
19.		*Zapada* sp.
	Family:	Perlodidae
20.		*Cultus* sp.
21.		*Isoperla* sp.
22.		*Kogotus* sp.
23.		*Megarcys* sp.
	Family:	Pteronarcydae
24.		*Pteronarcella* sp.
	Family:	Taeniopterygidae
25.		*Brachyptera* sp.
	Order:	Ephemeroptera
	Family:	Baetidae
26.		*Baetis* sp.
	Family:	Ephemerellidae
27.		*Ephemerella* sp. unid.
28.		*Ephemerella* sp. juve.
29.		*Ephemerella doddsi*
30.		*Ephemerella inermis*
31.		*Ephemerella infrequens*?
32.		*Ephemerella proserpina*
	Family:	Heptageniidae
33.		*Cinygmula* sp.
	Family:	Siphlonuridae
34.		*Ameletus* sp.
	Order:	Trichoptera
	Family:	Brachycentridae
35.		*Brachycentrus* sp.
	Family:	Glossosomatidae
36.		*Agapetus* sp.
	Family:	Hydropsychidae
37.		*Arctopsyche* sp.

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BOTTOM FAUNA AT CYPRUS ANVIL, SEPTEMBER, 1983 (continued)

	Family:	Hydroptilidae
38.		Hydroptila sp.
	Family:	Lepidostomatidae
39.		Lepidostoma sp.
	Family:	Limnephilidae
40.		Hesperophylax
41.		Onocosmoecus sp.
42.		Unidentify Limnephilidae
	Family:	Rhyacophilidae
43.		Rhyacophila sp.
	Order:	Diptera
44.	Family:	Ceratopogonidae
45.		Palpomya sp.
46.	Family:	Chironomidae (pupae)
47.		Brillia sp.
48.		Cardiocladius sp.
49.		Corynoneura sp.
50.		Cricotopus sp.
51.		Diamesa sp.
52.		Eukiefferiella sp.
53.		Heterotrissocladius sp.
54.		Microspectra sp.
55.		Monodiamesa sp.
56.		Paralauterborniella sp.
57.		Phaenopsectra sp.
58.		Polypedilum sp.
59.		Procladius sp.
60.		Tribelos sp.
61.	Family:	Empididae pupae
62.		Chelifera sp.
63.		Clinocera sp.
	Family:	Muscidae
64.		Limnophora sp.
65.		Lispe sp.
	Family:	Psychodidae
66.		Pericoma sp.
	Family:	Simuliidae
67.		Cnephia sp.
68.		Ectemnia sp.
69.		Prosimulium sp.

APPENDIX IV TABLE 1 TAXONOMIC LIST OF THE BOTTOM FAUNA AT CYPRUS ANVIL, SEPTEMBER, 1983 (continued)

	Family:	Tipulidae
70.		*Antocha* sp.
71.		*Tipula* sp.
	Order:	Coleoptera
72.		Unid. larva
	Phylum:	Mollusca
	Class:	Gastropoda
	Order:	Basommatophora
	Family:	Lymnaeidae
73.		*Lymnaea* sp.
	Order:	Ctenobranchiata
	Family:	Valvatidae
74.		*Valvata* sp.
	Order:	Pelecypoda
	Family:	Sphaeriidae
75.		*Pisidium* sp.

APPENDIX IV TABLE 2 CYPRUS ANVIL MACRO-INVERTEBRATE DATA - SEPTEMBER 1983

Taxonomic Group	STATION 1 #	1 %	2 #	2 %	3 #	3 %	4 #	4 %	5 #	5 %	6a #	6a %	7a #	7a %	9 #	9 %	10 #	10 %
1. Hydra sp.	23	(0.82)	-		-		-		-		-		-		-		-	
* 2. Nematoda	7		-		2		4		6		1		6		2		3	
* 3. Enchytraeidae	1		-		1		7		7		2		3		10		9	
4. Peranais sp.	2	(0.07)	-		-		-		-		-		-		-		-	
5. Nais sp.	16	(0.57)	-		-		-		-		-		-		1	(0.05)	-	
* 6. Tubificidae	5		-		-		-		-		-		-		1		-	
* 7. Daphnia rosea	6		-		-		1		1		-		-		-		-	
* 8. Cyclops sp.	13		1		2		1		2		1		-		-		-	
* 9. Diaptomus sp.	1		1		-		1		1		-		-		-		-	
*10. Ostracoda	7		-		-		-		1		-		-		-		-	
*11. Acari	7		1		-		4		10		-		16		5		29	
*12. Arachnida	1		-		-		-		-		-		-		-		-	
*13. Isotomidae	2		-		-		-		-		1		-		-		-	
14. Capnia sp.	157	(5.63)	45	(1.41)	2	(0.09)	70	(1.36)	50	(0.93)	438	(18.80)	135	(6.65)	882	(42.71)	4172	(59.74)
15. Kathroperla sp.	-		-		-		18	(0.35)	18	(0.33)	14	(0.60)	1	(0.05)	15	(0.73)	-	
16. Alloperla sp.	31	(1.11)	-		-		37	(0.72)	70	(1.30)	14	(0.60)	13	(0.64)	1	(0.05)	2	(0.03)
17. Amphinemura sp.	78	(2.79)	105	(3.29)	-		208	(4.04)	38	(0.71)	42	(1.80)	14	(0.69)	1	(0.05)	10	(0.14)
18. Prostoia sp.	6	(0.21)	11	(0.34)	-		38	(0.74)	40	(0.74)	4	(0.17)	2	(0.10)	3	(0.15)	4	(0.06)
19. Zapada sp.	119	(4.26)	296	(9.26)	3	(0.13)	1495	(29.05)	791	(14.71)	305	(13.09)	201	(9.90)	10	(0.48)	136	(1.95)
20. Cultus sp.	35	(1.25)	-		-		-		2	(0.04)	3	(0.13)	1	(0.05)	20	(0.97)	5	(0.07)
21. Isoperla sp.	7	(0.25)	102	(3.19)	-		145	(2.82)	195	(3.63)	55	(2.36)	5	(0.25)	3	(0.15)	32	(0.46)
22. Kogotus sp.	6	(0.21)	-		-		1	(0.02)	4	(0.07)	37	(1.59)	47	(2.32)	-		1	(0.01)
23. Megarcys sp.	-		2	(0.06)	-		21	(0.41)	24	(0.45)	29	(1.24)	1	(0.05)	-		-	
24. Pteronarcella sp.	-		-		-		2	(0.04)	10	(0.19)	19	(0.82)	-		7	(0.34)	5	(0.07)
25. Brachyptera sp.	16	(0.57)	717	(22.43)	2	(0.09)	97	(1.88)	63	(1.17)	29	(1.24)	18	(0.89)	135	(6.54)	24	(0.34)
26. Beetle sp.	572	(20.49)	743	(23.25)	4	(0.18)	1461	(28.39)	1899	(35.32)	430	(18.45)	340	(16.75)	129	(6.25)	90	(1.29)
27. Ephemerella sp. unid.	3	(0.11)	-		-		3	(0.06)	1	(0.02)	-		-		-		-	
28. Ephemerella sp. juven.	19	(0.68)	4	(0.13)	-		-		1	(0.02)	3	(0.13)	13	(0.64)	1	(0.05)	19	(0.27)
29. Ephemerella doddsi	-		1	(0.03)	-		1	(0.02)	3	(0.06)	5	(0.21)	7	(0.34)	-		-	
30. Ephemerella inermis	32	(1.15)	11	(0.34)	-		23	(0.45)	12	(0.22)	28	(1.20)	163	(8.03)	6	(0.29)	23	(0.33)

* Taxonomic level not included in the Shannon-Weiner diversity index (H') for bottom fauna, and the calculation of the percent similarity index (PSc).

Numbers of organisms sampled at each station.

% Percent abundance of organisms sampled at each station.

APPENDIX IV TABLE 2 CYPRUS ANVIL MACRO-INVERTEBRATE DATA - SEPTEMBER 1983 (Continued)

Taxonomic Group	STATION 1 #	1 %	2 #	2 %	3 #	3 %	4 #	4 %	5 #	5 %	6a #	6a %	7a #	7a %	9 #	9 %	10 #	10 %
31. Ephemerella infrequens	3	(0.11)	1	(0.03)	-		-		-		-		-		34	(1.65)	10	(0.14)
32. Ephemerella proserpina	6	(0.21)	-		-		-		1	(0.02)	3	(0.13)	8	(0.39)	-		4	(0.06)
33. Cinygmula sp.	76	(2.72)	43	(1.35)	-		380	(7.38)	403	(7.49)	409	(17.55)	314	(15.47)	60	(2.91)	21	(0.30)
34. Ameletus sp.	11	(0.39)	4	(0.13)	-		2	(0.04)	1	(0.02)	-		5	(0.25)	136	(6.59)	63	(0.90)
35. Brachycentrus sp.	1	(0.04)	1	(0.03)	-		8	(0.16)	23	(0.43)	5	(0.21)	11	(0.54)	4	(0.19)	128	(1.83)
36. Agapetus sp.	1	(0.04)	-		-		37	(0.72)	-		1	(0.04)	-		-		2	(0.03)
37. Arctopsyche sp.	-		2	(0.06)	1	(0.04)	-		13	(0.24)	222	(9.53)	49	(2.41)	3	(0.15)	7	(0.10)
38. Hydroptila sp.	-		-		-		-		-		-		-		2	(0.10)	-	
39. Lepidostoma sp.	-		-		-		-		-		-		-		-		1	(0.01)
40. Hesperophylax sp.	2	(0.07)	-		-		-		-		1	(0.04)	-		-		2	(0.03)
41. Oncocosmoecus sp.	-		-		-		-		-		-		-		-		6	(0.09)
*42. Limnephilidae unid.	-		-		-		-		2		5		1		1		13	
43. Rhyacophila sp.	7	(0.25)	2	(0.06)	-		3	(0.06)	3	(0.06)	26	(1.12)	-		-		1	(0.01)
*44. Ceratopogonidae	1		-		-		-		1		-		-		-		1	
45. Palpomya sp.	-		-		-		-		-		-		1	(0.04)	1	(0.05)	1	(0.01)
*46. Chironomidae pupae	65		4		3		11		1		5		38		50		368	
47. Brillia sp.	2	(0.07)	43	(1.35)	1090	(47.79)	4	(0.08)	-		-		-		2	(1.00)	25	(0.36)
48. Cardiocladius sp.	35	(1.25)	102	(3.19)	15	(0.66)	99	(1.92)	112	(2.08)	34	(1.46)	63	(3.10)	8	(0.39)	27	(0.39)
49. Corynoneura sp.	37	(1.33)	-		-		-		-		-		-		-		-	
50. Cricotopus sp.	76	(2.72)	29	(0.91)	10	(0.44)	7	(0.14)	2	(0.04)	11	(0.47)	417	(20.54)	324	(15.69)	1745	(24.99)
51. Diamesa sp.	1	(0.04)	-		1	(0.04)	-		-		-		-		-		1	(0.01)
52. Eukiefferiella sp.	-		53	(1.66)	-		180	(3.50)	77	(1.43)	5	(0.21)	18	(0.89)	4	(0.19)	7	(0.10)
53. Heterotrissocladius sp.	160	(5.73)	61	(1.91)	19	(0.83)	334	(6.49)	338	(6.29)	42	(1.80)	118	(5.81)	164	(7.94)	223	(3.19)
54. Micropsectra sp.	779	(27.91)	7	(0.22)	183	(8.02)	20	(0.39)	26	(0.48)	-		-		14	(0.68)	72	(1.03)
55. Monodiamesa sp.	-		1	(0.03)	7	(0.31)	-		-		-		-		-		-	
56. Paraeuterbornielia sp.	-		-		-		-		-		-		-		-		1	(0.01)
57. Phaenopsectra sp.	2	(0.07)	5	(0.16)	655	(28.72)	-		-		-		-		-		1	(0.01)
58. Polypedilum sp.	-		-		-		-		-		-		-		10	(0.48)	12	(0.17)
59. Procladius sp.	369	(13.22)	-		-		1	(0.02)	3	(0.06)	-		-		33	(1.60)	37	(0.53)
60. Tribelos sp.	1	(0.04)	-		-		-		-		-		-		-		3	(0.04)

* Taxonomic level not included in the Shannon-Weiner diversity index (H') for bottom fauna, and the calculation of the percent similarity index (PSc).

Numbers of organisms sampled at each station.

% Percent abundance of organisms sampled at each station.

APPENDIX IV TABLE 2 CYPRUS ANVIL MACRO-INVERTEBRATE DATA - SEPTEMBER 1983 (Continued)

Taxonomic Group	STATION								
	1	2	3	4	5	6a	7a	9	10
	# %	# %	# %	# %	# %	# %	# %	# %	# %
*61. Empididae pupae	-	-	-	12	27	-	-	-	-
62. Chelifera sp.	-	-	-	1 (0.02)	7 (0.13)	-	-	-	-
63. Clinocera sp.	2 (0.07)	-	-	-	-	-	-	-	11 (0.16)
64. Limnophora sp.	-	1 (0.03)	254 (11.14)	-	-	-	-	-	-
65. Lispe sp.	1 (0.04)	-	3 (0.13)	-	-	-	-	-	-
66. Pericoma sp.	10 (0.36)	-	1 (0.04)	3 (0.06)	8 (0.15)	4 (0.17)	16 (0.79)	-	31 (0.44)
67. Cnephia sp.	5 (0.18)	128 (4.01)	-	32 (0.62)	25 (0.46)	7 (0.30)	8 (0.39)	6 (0.29)	-
68. Ectemnia sp.	-	1 (0.03)	-	6 (0.12)	3 (0.06)	-	-	-	-
69. Prosimulium sp.	30 (1.07)	675(21.12)	-	391 (7.60)	1091(20.29)	94 (4.03)	38 (1.87)	47 (2.28)	18 (0.26)
70. Antocha sp.	7 (0.25)	-	31 (1.36)	18 (0.35)	19 (0.35)	1 (0.04)	3 (0.15)	-	1 (0.01)
71. Tipula sp.	1 (0.04)	-	-	-	1 (0.02)	-	-	-	-
*72. Coleoptera larva	-	-	-	-	-	1	-	-	-
73. Lymnaea sp.	2 (0.07)	-	-	-	-	-	-	-	-
74. Valvata sp.	42 (1.50)	-	-	-	-	-	-	-	-
75. Pisidium sp.	1 (0.04)	-	-	-	-	-	-	-	-
N Total of individuals	2907 (100)	3203 (100)	2289 (100)	5187 (100)	5436 (100)	2336 (100)	2094 (100)	2135 (100)	7407 (100)
N_m Number of individuals per m^3-density	170,000	187,310	133,860	303,333	317,895	136,608	122,456	124,854	433,158
N_g Total of individuals on a generic level for bottom fauna	2791	3196	2281	5146	5377	2320	2030	2065	6984
G Total of genera identified	41	26	17	31	32	27	26	29	37
H' Diversity Index	1.07	0.93	0.60	0.93	0.87	1.02	1.03	0.88	0.59
J' Evenness	0.66	0.66	0.49	0.62	0.58	0.71	0.73	0.60	0.38

* Taxonomic level not included in the Shannon-Weiner diversity index (H') for bottom fauna, and the calculation of the percent similarity index (PSc).

Numbers of organisms sampled at each station.

% Percent abundance of organisms sampled at each station.

APPENDIX V

ATTACHED ALGAE DATA

APPENDIX V TABLE 1 ATTACHED ALGAL - EXTRACTABLE METALS - STATION 3

	DATE	$\bar{x}$ S.D.	Al mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Ca mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Mg mg/kg
Wet Weight	83/7/26		373	28.0	46.7	<0.050	3670	2.20	-	1.60	5.4	9030	294
	83/9/15	$\bar{x}$	269	12.7	33.6	<0.050	1500	0.26	23.4	1.47	4.97	8690	288
		S.D.	67.6	2.6	6.6	.006	204	0.03	5.8	0.2	0.15	872	25.0
Dry Weight	83/7/26		2040	150	255	<0.30	20100	11.8	-	9.00	29.0	49300	1610
	83/9/15	$\bar{x}$	1450	70	180	<0.23	8090	1.50	126	8.00	27.0	46900	1570
		S.D.	323	10.0	22.0	0.06	451	0.2	24.2	1.0	2.65	1180	218

	DATE		Mn mg/kg	Mo mg/kg	Na mg/kg	Ni mg/kg	Pb mg/kg	Sb mg/kg	Si mg/kg	Sn mg/kg	Sr mg/kg	Ti mg/kg	V mg/kg	Zn mg/kg
Wet Weight	83/7/26		264	<0.20	140	6.0	5.0	<2.0	13.0	2.8	12.9	7.9	3.7	56.4
	83/9/15	$\bar{x}$	559	<0.23	134	2.7	2.9	<2.3	12.3	2.9	6.11	6.2	1.7	25.5
		S.D.	47.5	.06	21.1	0.6	0.4	0.6	12	0.8	0.7	1.6	0.2	2.9
Dry Weight	83/7/26		1440	<0.10	750	33.0	29.0	<10.0	70.0	15.0	70.2	43.4	20.0	308
	83/9/15	$\bar{x}$	3020	<0.10	733	14.6	16.3	<10.0	70.0	15.7	33.0	33.3	9.0	137
		S.D.	116	0.0	162	1.5	1.2	0.0	0.0	5.7	1.6	1.6	1.0	3.8

$\bar{x}$ - arithmetic mean
S.D.- standard deviation

APPENDIX VI

ENVIRONMENTAL COMPLIANCE MONITORING DATA

APPENDIX VI TABLE 1a CAMC - HISTORICAL WATER QUALITY DATA
(Values in mg/L unless otherwise stated, metals extractable)
- Station x-3 = EPS 1

SOURCE	DATE	pH	TEMP C°	FLOW (m^3/s)	NFR	COND. (umhos/cm)	COLOR (c. unit)	TURBIDITY (FTU)	TOTAL ALKALINITY	TOTAL HARDNESS	CN	NH_3
*EPS/DIAND	1974 Average	7.7	-	-	691	193	40.0	36.0	95	102	-	-
*EPS/DIAND	1975 Average	7.9	-	-	536	160	40.0	75.0	65	73	-	-
*EPS/DIAND	1976 Average	7.5	-	-	46.0	129	20.0	5.0	67	72	-	-
Weagle STA R-1 (CAMC)	August 16 & 19 1980	7.4	11	-	-	105	-	-	-	-	0.010	0.350
EPS STA 3	Aug. 26/80	8.0	7	-	19.0	174	10.0	3.0	75	76	0.090	0.0050
CAMC (Klohn Leonoff)	Sept/81	7.1	1	-	0	130	5.0	2.0	106	-	<0.020	0.330
EPS	July 26, 1983	7.3	9	0.997	<5.0	70	10.0	0.2	56	50	-	0.0070
EPS	Sept. 15, 1983	7.7	7	-	<5.0	90	7.5	0.1	62	72	-	0.0095

* Averages determined from data presentaton EPS Region Program Report 79-25 for Station 1 (Baker 1979).

EPS - Environmental Protection Service
DIAND - Department of Indian Affairs and Northern Development
CAMC - Cyprus Anvil Mining Corporation

APPENDIX VI TABLE 1a CAMC - HISTORICAL WATER QUALITY DATA
(Values in mg/L unless otherwise stated, metals extractable) (Continued)
- Station x-3

SOURCE	DATE	As	Ca	Cu	Fe	Mg	Mn	Na	Pb	SO_4	Zn
*EPS/DIAND	1974 Average	-	-	0.010	3.10	-	0.180	-	0.020	13.2	0.28
*EPS/DIAND	1975 Average	-	-	0.020	1.80	-	0.270	-	0.090	23.8	0.12
*EPS/DIAND	1976 Average	-	-	<0.010	0.48	-	0.080	-	0.020	8.7	0.06
Weagle STA R-1 (CAMC)	August 16 & 19 1980	-	18.0	0.030	0.30	4.00	0.120	3.0	0.51	-	0.19
EPS STA 3	Aug. 26/80	<0.015	22.5	<0.010	0.16	4.80	0.050	2.2	<0.080	10.8	0.04
CAMC (Klohn Leonoff)	Sept/81	0.200	26.0	0.010	0.16	7.51	0.090	3.0	0.0200	-	0.50
EPS	July 26, 1983	<0.0050	15.1	0.002	0.17	2.80	0.014	1.0	<0.0010	8.4	0.03
EPS	Sept. 15, 1983	<0.0050	22.2	0.017	0.16	3.90	0.019	1.6	0.0020	10.4	0.133

* Averages determined from data presentaton EPS Region Program Report 79-25 for Station 1 (Baker 1979).

EPS - Environmental Protection Service
DIAND - Department of Indian Affairs and Northern Development
CAMC - Cyprus Anvil Mining Corporation

APPENDIX VI TABLE 1b CAMC - HISTORICAL WATER QUALITY DATA
(Values in mg/L unless otherwise stated, metals extractable)
- Station x-14, EPS

SOURCE	DATE	pH	TEMP C°	FLOW (m^3/s)	NFR	COND. (umhos/cm)	COLOR	TURBIDITY	TOTAL ALKALINITY	TOTAL HARDNESS	CN	NH_3
*EPS/DIAND	1974 Average	7.7	-	-	252	275	75	78	73	88	-	-
*EPS/DIAND	1975 Average	7.7	-	-	267	279	22	49	65	95	-	-
*EPS/DIAND	1976 Average	7.7	-	-	11.0	407	16	2	91	121	0.188	-
Beagle STA R-3 (CAMC)	August 16, 1980	7.9	10	-	-	221	-	-	-	-	0.010	0.240
**EPS STA 1	Aug. 26/80	7.8	6	-	<5.0	400	23	2	100	119	0.050	0.104
EPS STA 4	July 26, 1983	7.7	10	3.11	<5.0	180	5	0.10	77	103	-	0.024
EPS STA 4	Sept. 15, 1983	7.9	4.5	-	<5.0	170	5	0.10	88	122	-	0.036

* Averages determined from data presentaton EPS Region Program Report 79-25 for Station 1 (Baker 1979).
**3-day average calculated from Station 3 data. This station was located d/s of decant and u/s of present day diversion canal confluence with Rose Creek.

EPS - Environmental Protection Service
DIAND - Department of Indian Affairs and Northern Development
CAMC - Cyprus Anvil Mining Corporation

APPENDIX VI TABLE 1b CAMC - HISTORICAL WATER QUALITY DATA
(Values in mg/L unless otherwise stated, metals extractable) (Continued)
- Station x-14

SOURCE	DATE	As	Ca	Cu	Fe	Mg	Mn	Na	Pb	SO_4	Zn
*EPS/DIAND	1974 Average	0.18	-	0.091	1.6	-	0.50	-	0.08	70.3	0.08
*EPS/DIAND	1975 Average	-	30.0	0.021	3.3	6.8	0.79	-	0.14	105	0.08
*EPS/DIAND	1976 Average	0.0010	35.7	0.038	0.44	5.7	-	-	0.07	138	0.18
Weagle STA R-1 (CAMC)	August 16, 1980	-	32.0	0.01	0.34	7.0	0.80	20	0.08	-	0.20
**EPS STA 1	Aug. 26/80	<0.015	35.0	<0.010	0.71	7.6	1.4	33	<0.080	91.0	0.07
EPS STA 4	July 26, 1983	0.00070	30.6	0.002	0.15	6.2	0.26	8	<0.0010	49.9	0.06
EPS STA4	Sept. 15, 1983	<0.00050	37.0	0.015	0.15	7.0	0.44	12	0.0020	59.3	0.10

* Averages determined from data presentaton EPS Region Program Report 79-25 for Station 1 (Baker 1979).
**3-day average calculated from Station 3 data. This staton was located d/s of decant and u/s of present day diversion canal confluence with Rose Creek.

EPS - Environmental Protection Service
DIAND - Department of Indian Affairs and Northern Development
CAMC - Cyprus Anvil Mining Corporation

APPENDIX VI TABLE 1c CAMC - HISTORICAL WATER QUALITY DATA
(Values in mg/L unless otherwise stated, metals extractable)
- Station x-15, EPS

SOURCE	DATE	pH	TEMP C°	FLOW (m^3/s)	NFR	COND. (umhos/cm)	COLOR	TURBIDITY	TOTAL ALKALINITY	TOTAL HARDNESS	CN	NH_3
*EPS	Sept. 16, 1974	7.9	1	-	6.5	172	5	58	91	77	-	-
*EPS	Aug/Sept Average 1975	7.5	5/3	-	32.0	215	6	6	81	98	-	-
*EPS	July/Aug Average 1976	7.7	8/10	-	5.0	110	18	1.4	76	69	<0.030	-
EPS STA 5	July 26, 1983	7.7	10	3.02	<6.7	180	5	0.1	79	106	-	0.018
EPS STA 6a	Sept. 15, 1983	7.9	4.5	-	-	170	7.5	0.1	90	123	-	0.031

* Averages determined from data presentaton EPS Region Program Report 79-25 for Station 1 (Baker 1979).

EPS - Environmental Protection Service

APPENDIX VI TABLE 1c CAMC - HISTORICAL WATER QUALITY DATA
(Values in mg/L unless otherwise stated, metals extractable) (Continued)
- Station x-15

SOURCE	DATE	As	Ca	Cu	Fe	Mg	Mn	Na	Pb	SO_4	Zn
*EPS	Sept. 16, 1974	-	-	<0.010	0.51	-	0.44	-	0.04	-	0.06
*EPS	Aug/Sept Average 1979	-	28.0	<0.020	1.90	6.6	-	-	<0.020	-	0.03
*EPS	July/Aug Average 1976	<0.020	18.0	0.010	0.33	6.0	-	-	0.04	-	0.06
EPS STA 5	July 26, 1983	<0.00050	31.6	0.0020	0.13	6.3	0.22	8	<0.0010	48.8	0.05
EPS STA 6a	Sept. 15, 1983	<0.00050	37.2	0.012	0.14	7.0	0.38	11	0.0020	55.3	0.12

* Averages determined from data presentaton EPS Region Program Report 79-25 for Station 1 (Baker 1979).

EPS - Environmental Protection Service